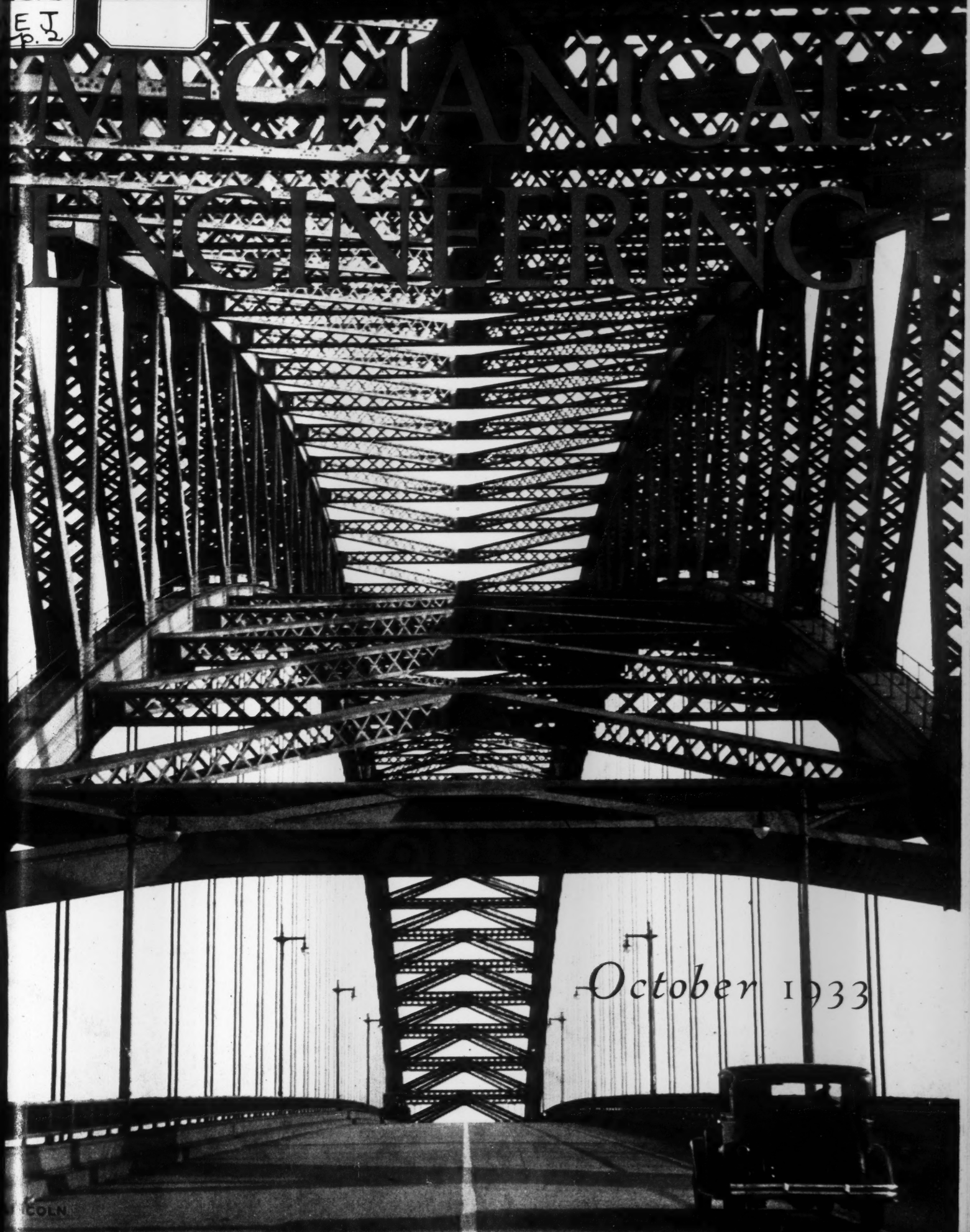
20.6
E J
p.2
R.R.

MECHANICAL ENGINEERING



October 1933

EIGHT DIVIDENDS . .
ONE BOILER METER

1 On boilers of 100 h. p. or larger, the Bailey Boiler Meter produces a notable saving in fuel by guiding the way to best combustion efficiency.

2 Deterioration of furnace wall refractories is decreased, since excessive furnace temperatures are prevented.

3 Boiler capacity increases, thereby postponing and sometimes eliminating the necessity of enlarging the plant.

4 One Bailey Boiler Meter fills a threefold need . . . it is a Combustion Guide, a Steam Flow Meter, and a Flue Gas Temperature Recorder.

5 All records are made on a single uniformly graduated chart permitting easy, timesaving comparisons of related factors.

6 The meter tells when the boiler should be cut out of service for tube cleaning or repairing of the baffles.

7 Reliable data and permanent records are furnished for the Cost Accounting System.

8 Each Bailey Boiler Meter is designed to fit the particular installation to assure maximum effectiveness.

These dividends may amount to hundreds of dollars yearly in your plant. Write for bulletin No. 43a, which gives examples of actual savings made by the installation of Bailey Boiler Meters.

D-7

BAILEY METER CO.

1026 IVANHOE ROAD CLEVELAND, OHIO.

Bailey Meter Company Limited, Montreal, Canada

MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 55 NUMBER 10

Contents for October, 1933

THE COVER	BAYONNE BRIDGE	
THE PROBLEM OF PURCHASING POWER	*R. E. Flanders*	595
MEASURING OUR CAPABILITIES	*C. W. Squier*	603
ECONOMIC LOT SIZES IN MANUFACTURING	*P. T. Norton, Jr.*	608
PROBLEMS IN FAST AIR-TRANSPORT DESIGN	*H. L. Hibbard*	611
INDUSTRY AND GOVERNMENT		618
THE CONTROL OF INDUSTRIAL DUST	*J. M. DallaValle*	621
CORRELATION OF METAL-CUTTING DATA	*R. C. Deale*	625

EDITORIAL	628	CORRESPONDENCE	645
SURVEY OF ENGINEERING PROGRESS	630	BOOK REVIEWS	652
SYNOPSES OF A.S.M.E. PAPERS	643	WHAT'S GOING ON	655

DISPLAY ADVERTISEMENTS	1	CLASSIFIED ADVERTISEMENTS	26
PROFESSIONAL SERVICE	25	INDEX TO ADVERTISERS	28

OFFICERS OF THE SOCIETY:

A. A. POTTER, *President*

ERIK OBERG, *Treasurer* CALVIN W. RICE, *Secretary*

PUBLICATION STAFF:

GEORGE A. STETSON, *Editor* FREDERICK LASK, *Advertising Mgr.*

COMMITTEE ON PUBLICATIONS:

L. C. MORROW, *Chairman* S. W. DUDLEY

S. F. VOORHEES, *Vice-Chairman* W. F. RYAN

M. H. ROBERTS

C. E. DAVIES, *Secretary to Committee on Publications*

ADVISORY MEMBERS OF THE COMMITTEE ON PUBLICATIONS:

E. L. OHLE, ST. LOUIS, MO. E. B. NORRIS, BLACKSBURG, VA. A. J. DICKIE, SAN FRANCISCO, CALIF.

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 60 cents a copy, $5.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage to Canada, 75 cents additional, to foreign countries, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B2, Par. 3). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . . Copyrighted, 1933, by The American Society of Mechanical Engineers.

Ready for Service

The Problem of
PURCHASING POWER

By RALPH E. FLANDERS[1]

IT IS THE practise of the engineer to deal simultaneously with theory and with concrete problems. His ability to do so is what makes him an engineer, rather than a scientist, or a mechanic and inventor. His professional existence depends on his ability to find his way about in these two worlds.

This being true, no excuse to this audience is needed for describing an incursion into economic theory in terms of a practical problem. Indeed, may it not be true that concentration on a pressing problem is the greatest service than can be rendered at this time to the development of economic research and resulting economic theory?

With this thought in mind, the second progress report[2] of the Committee on Economic Balance of the American Engineering Council ventured to set objectives for economic control. The objectives were expressed thus:

(*a*) A decrease in the violence of the fluctuations in the volume of goods produced and consumed; that is, an increase in stability.

(*b*) An increase in the average rate of production and consumption; that is, a rise in the general scale of living.

(*c*) A wider distribution of goods produced.

This is a fair statement of the threefold problem of purchasing power with which contemporary economics is, or should be, preoccupied.

We must beware of the acceptance on the part of industry of anything like full responsibility for the sum total of economic evils. This full responsibility must be disavowed vigorously and unremittingly, while we continue with willingness to accept such responsibility as does belong to us. That we should continuously call attention to the major evils which lie within the areas of government and financial activity is a public duty. Otherwise those evils will fail of their proper attention and we shall be launched on an era of minute governmental control of business from which no good can come and from which we may never escape.

The whole of this analysis casts doubt on the necessity for discarding incontinently the institutions which have brought us to the hopeful position we occupy today. The required sections are seen to be of a type which frees our system from disturbing forces, as opposed to policies which would force it by herculean and endless effort into predetermined molds. The unnatural strain of the effort we are making is already too apparent.

It is worth while that there should be made this high-hearted experiment of a purposeful recovery, based directly and humanely on a revival of mass purchasing power instead of indirectly on a revival of profit. There is reason to hope that it will succeed. But there is no hope that the normal development of business and the longed-for improvements in the scale of living for the masses can be attained by an indefinite continuance of this tension of detailed control.

THE NORMAL PROCESS

There is an ideal condition in which the requirements of stability and improvement in the scale of living are completely met. This has been described thus:[3]

> In times when industry and commerce as a whole are running along on even keel, neither expanding nor contracting their operations, and neither adding to nor drawing on their surplus, the acts of extraction, manufacture, and distribution of goods finance their purchase by the general public. For the receipts from the monthly sales are all paid out in wages, salaries, and dividends, for materials and supplies, repair and replacement of equipment, taxes, insurance, and other services. If the firms and individuals to whom these sums are paid are likewise neither saving nor drawing on savings, but spending all they receive, the whole process is completely self-supporting. This I take to be a commonplace of classic economics.
>
> Expansion of activity can take place without upsetting the balance, which may thus be dynamic rather than static. For if, instead of paying out dividends, a company finds it expedient to spend its profits in expanding its plant and making additional expenditures for more material and increased labor for a larger work-in-process account, the increased expenditures go into the general pool of purchasing power to finance the initial purchase of the increased output, which then balances as before, but at a higher level. All of this, of course, supposes that the product is salable and that increased labor hours are available. We are describing purely ideal conditions.

---

[1] President, Jones & Lamson Machine Co., Springfield, Vt. Mem. A.S.M.E.

[2] MECHANICAL ENGINEERING, April, 1933, pp. 211–224.

An address delivered at Johnsonburg, N. J., August 20, 1933, at the Third Economic Conference for Engineers, held under the auspices of the Stevens Institute of Technology, with the A.S.M.E. and other engineering societies and university alumni associations cooperating.

[3] "Limitations and Possibilities of Economic Planning," *Annals*, American Academy of Political and Social Science, July, 1932.

The increased output from the reinvested profits may result in lower costs and prices for a given unit expenditure, in which case the general scale of living is raised; or, as probably, the reinvestment is for more efficient equipment, which permits an even greater favorable readjustment as between prices on the one hand and wages, salaries, profits, etc., on the other.

Income distribution, the third element of the problem, is neglected for the time being in this analysis.

I—MAJOR ELEMENTS OF UNBALANCE

The limits of time and space, and other limitations as well, prevent anything more than a hasty and incomplete examination of the next element of analysis—a study of the factors which interfere with these normal processes.

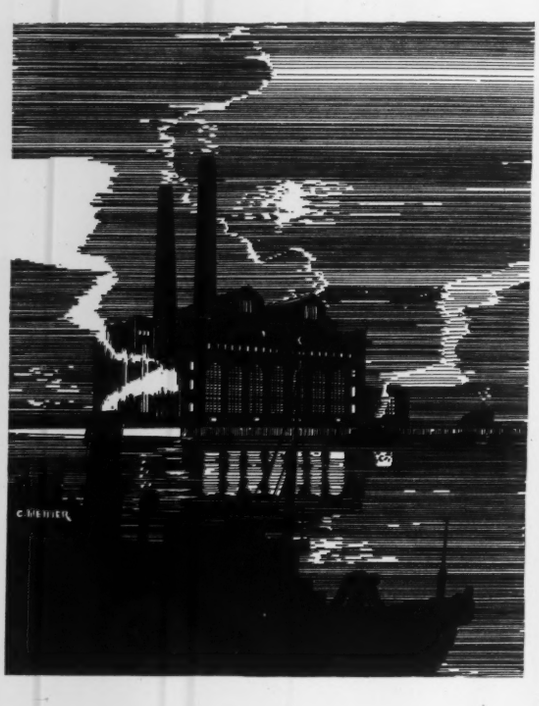
INFLATION AND DEFLATION

Of these factors the most interesting and amazing is an induced flow of purchasing power to the market which is greater or less in rate than the flow of goods which are to be purchased. The term used for specifying such an increase in flow of funds is "inflation;" and for a decrease, "deflation."

During an inflation, with funds appearing faster than goods, the tendency is for the general price level to rise. During the subsequent deflation, with goods appearing faster than funds, the tendency is for prices to fall.

The most far-reaching and intractable example of inflation is that employed in financing war. This expansion of funds is carried out in many ways. One of the particularly interesting kinds was employed for floating war bonds, with which most of us had experience. Bonds might have been purchased out of savings, in which case there would have been no inflation involved. But this process was too slow and limited. We were urged to go to the banks and borrow money to buy a bond with, depositing the bond itself as security.

Now the interesting thing about ordinary commercial borrowing at the bank is that it is a process of making money—a kind of legalized and not necessarily dangerous counterfeiting. When a transaction of this sort has been completed, the note is entered on one side of the books as an asset, and the sum borrowed is credited to the borrower's account as a liability. This is *new money*. Not as a rule any one's previous savings, but bank-credit-money conjured out of the empty air. There are, of course, legal safeguards to the process, but it is essentially magical, and adds to the rate of flow of funds coming to market.



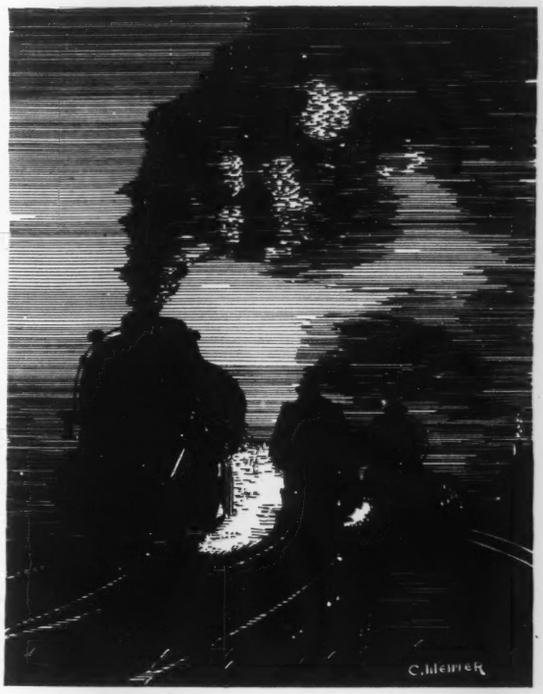
Of course, in the particular transaction of financing the purchase of war bonds, the funds are promptly credited to the account of the Government, and the bond itself is left to the credit of the borrower; but the inflation of funds is just as definite.

Such an inflation of active funds leads to a rise in prices, and the rise in prices acts as a stimulant to production, all as demanded by war conditions. Not only are existing facilities run at their full capacity, but the building of new factories is stimulated, to a degree in excess of available savings. The funds for the purpose are again furnished by bank borrowing—that is to say, they are manufactured out of thin air. The arrival of these funds in the market for goods again raises prices, and the self-generating cycle of inflation continues. In its progress, immense profits are made, based not only on the immense volume of war activity, but as well on the appreciation of all values involved in the steadily rising price level.

The total process of war inflation was more complicated than this, but it was of this nature; and being such, neither the price structure nor the profits long survived the demand for war goods, which ceased shortly after the armistice. The inflation and price-level rise were indeed continued into the middle of the year 1920 by the well-remembered commodity speculation, but this was more nearly akin to a typical cyclic disturbance, which will be described later.

After the war demand ceases; it is normal for credit inflation to cease and to reverse. Debts are being paid up instead of being incurred, and in the process, the volume of bank credit is being diminished. Credit-money is extinguished as definitely as paper currency would be if it were destroyed. The immediate result is to lower the quickly responsive wholesale prices, and later, through "buyers' strikes" and otherwise, the whole range of retail prices. This reduces or destroys profits, closes factories, causes bankruptcies, and generates unemployment.

The war was, then, financed in part by savings, but principally by credit inflation which ran its course and then retraced through a deflationary period. What was the effect on our major problem, the scale of living?



On its stability, the effect of war inflation and subsequent deflation is obvious. The volume of money is increased and decreased, as is its rate of circulation and the manufacture and distribution of goods. The price level is raised and lowered. Incomes are raised and lowered. Debts are incurred and paid off. All of these changes take place, not in that even step, each with each, which would represent a kind of dynamic balance, but in such wise as to accelerate and intensify the elements of unbalance and lead to destructive oscillations in the total economic process.

The effects on the rise in the scale of living are not so clear cut. There still progresses that improvement in efficiency of production and distribution on which our hopes for better living ultimately depend. There is reason to believe that a moderate fluctuation in business is stimulating to the impulse for improvement. There is no reason to believe that the violence of change induced by war financing and recovery is anything but destructive to progress in social standards.

The effect on the distribution of wealth is indubitably undesirable. The credit-expanding, debt-incurring, price-raising cycle is such that obligations are incurred at high price and income levels by the active factors in the business mechanism, which have to be repaid in a resulting period of low prices and incomes, with a resulting paralysis of business, consumer incomes, and even of subsistence itself. The mechanism operates to extinguish purchasing power in part, and in part to transfer it to a creditor class which is only in a limited degree coincident with the debtor class.

One element of the war finance disaster deserves special consideration. That is its effect on agriculture. The official pressure for agricultural expansion was particularly strong. As a result, young and enterprising farmers took over large acreages from older ones, on mortgages, at values based on inflation prices. The policy was effective in its immediate results, but left farmers with an undue proportion of the resulting burden of debt. The increased production from the new land brought under cultivation, when added to the revival of production in the belligerent countries, played its part in lowering prices and decreasing the ability of the farmer to meet indebtedness.

The third important contribution of the war to our current distresses lies in its destruction of what was a fairly smoothly operating mechanism of foreign trade and international finance. The burden of international indebtedness is if anything more intractable and disturbing than the domestic burden which has been described. The typical post-war nationalism has set up new trade barriers on new frontiers and raised those on the old ones. Disturbed political conditions disrupt the flow of funds and goods as national credits ebb and flow.

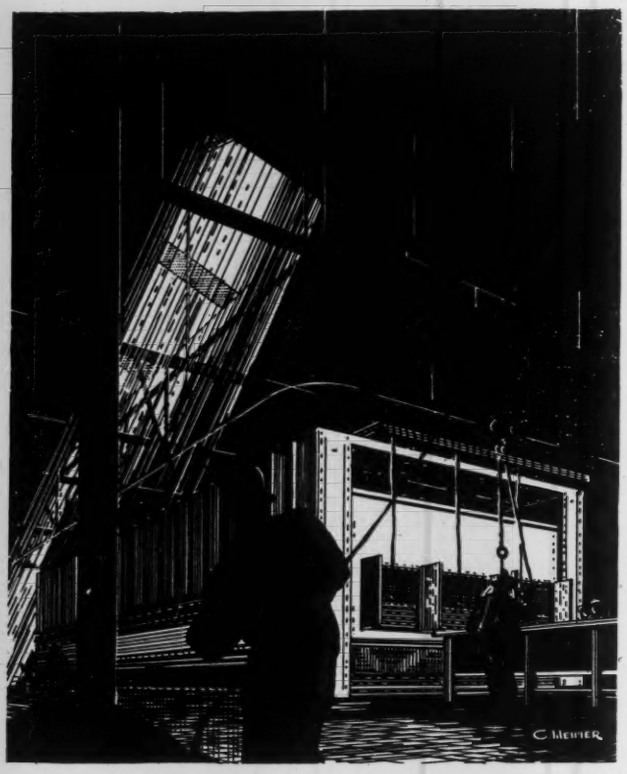
If we consider the three major phenomena just described—monetary and agricultural inflation and post-war disorganization—and trace their effects during and after the two previous periods of general warfare—the Napoleonic wars, and the mid-century disturbances of which our own Civil War was the culminating feature—if we review history in this manner, we find that much of our recent experience which we thought to be new is very old indeed, and we are led to wonder why it was not all foreseen long before.

Mercifully, having taken the plunge, we were spared that foresight. In sober truth, "war is hell"—not only while it is being waged, but for a generation afterward.

CREDIT INFLATION AND THE BUSINESS CYCLE

After the armistice, credit inflation was supported and extended for a time by governmental fiscal policies, and industrial activity was maintained temporarily by the inertia of war contracts. There was in consequence no interval between the war inflation and a short industrial and speculative boom based on the scarcity of the ordinary consumer goods, and the consequent demand for them. This boom collapsed in 1920. It presented many of the features of the boom phase of that rarest of phenomena, a typical business cycle. The important elements are, however, more easily discerned in the cycle extending from 1924 to the present time.

The first noticeable feature of this cycle is the purposefully maintained price level during that period, extending to the fall of 1929. During these 5 1/2 years, there was building up a towering mass of bank credit and of consequent debt on the one hand and of purchasing power on the other, which did indeed show itself in a moderately increased volume of business, but was not revealed in the price level. This fact, if squarely faced, must give pause to those who pin their faith on the control of the price level, whether by Federal Reserve policy, by continuous revaluation of the dollar, or by other means. Dating from October, 1929, these might have established policies favorably affecting readjustment, but there was a top-heavy structure to be sup-



ported whose erection should never have been permitted.

While there was no rise during this period in any general price index of commodities, there was a spectacular rise in security prices, and a concurrent speculative activity of unprecedented proportions. In the first progress report[4] of the American Engineering Council's committee, we assumed that the mass of purchasing power generated by productive activities and by credit expansion was in part diverted into the money market supporting this speculation, and was thus lost to purchasing power. This would have accounted for the ability to steady the price level. However, an article by Professor Eitemann on "Economics of Brokers' Loans"[5] was generally considered by economists to have demonstrated that purchasing power could not be so diverted into the operations in the market, but must inevitably and quickly show up as a demand for goods of some sort. As a result this contention was withdrawn in the second progress report.[6]

Still, the facts remain that immense sums were generated by credit inflation, that there was no effect of them visible in commodity prices, and that security prices acted exactly as commodities would have done had the speculative activity been concentrated on them as in 1920.

These considerations leave the matter in serious doubt. In spite of the convincing nature of the details of Professor Eitemann's argument, he arrives at conclusions which do not agree with the facts. I have recently been encouraged by reports that Professor Williams, of Harvard, and others have brought to light aspects which Professor Eitemann did not consider. I am, therefore, for the time assuming that the funds provided by the credit inflation of 1924–1929 were largely lost to purchasing power through short-circuiting in the speculative area.

While most of the credit-money and its debt were generated by well-known financial and business operations, a new factor appeared in the large expansion of instalment selling. This is like other credit inflation in being based on bank loans; it lends color to the belief in a failure in purchasing power for consumer goods during the inflation, in that it was stimulated by a widespread difficulty in disposing of the goods produced; and it brings home to the humblest citizen the dangers of easy credit and expanded purchasing power which has to be liquidated in a period of lower prices and incomes. Like all typical bank-loan operations, the funds are extinguished on repayment, and there is a net loss in purchasing power unless new loans of corresponding magnitude are being currently made.

All of these phenomena affect normal production and the consequent distribution of purchasing power in about the same way as did the factors dependent on war financing. The cyclic credit disturbance has the same effect on the stability, improvement, and distribution of the general scale of living. The seriousness of the situation was doubled by the fact that the new speculative and instalment indebtedness was added to the large residuary war indebtedness, and that the cyclic deflation joined hands with the war deflation and thereby progressed with redoubled violence.

RATIO BETWEEN SPENDING AND SAVING

The ratio between spending and saving is an important factor. From various viewpoints this has been studied by Foster and Catchings, J. A. Hobson, David C. Coyle, and, more recently, Dr. H. C. Dickinson, president of the Society of Automotive Engineers.

Too great a diversion of the monetary returns from business going into saving instead of into spending, into investment instead of into consumption, has at least three disturbing effects. It may initiate the credit inflation of a typical cycle, it retards the rate of production and distribution of consumer goods, and it is in itself an undesirable distribution of purchasing power.

We shall not have gained a useful conception of that form of money which we call bank credit unless we realize the unreliability of the forces which keep it in equilibrium. As already noted, it is generated by borrowing. The borrower's promise to pay is transmuted into the negotiable form of a checking account, and is sent out to do the business of the country. Its worth depends on the prospects of business. With hopeful prospects it expands easily, even uncontrollably. A breath of doubt, and its collapse is as easy and as uncontrollable.

The events leading to our recent inflation seem clear in retrospect. The period from 1924 on was one of unusually rapid improvement in production machinery

[4] MECHANICAL ENGINEERING, June, 1932, pp. 415–423.
[5] *Economic Review*, March, 1932.
[6] MECHANICAL ENGINEERING, April, 1933, pp. 211–224.

and processes and in business management. It seems probable that the element of initial cyclic unbalance lay in the large profits which resulted therefrom. Too large a share of the returns from industry went to the savers and investors and too little to the spenders and consumers. This resulted, first, in a tendency to build new plants in advance of the provision of purchasing power to absorb the goods produced; as the sufficiency of productive plant became evident, there followed a period in which funds flowed by preference into the securities of existing companies, which were bid up sky-high in the process; and, finally, there followed the manufacture and sale of secondary and tertiary securities of purely speculative earning power, based on the underlying *bona fide* earning stocks.

These last phenomena are but other aspects of the same inflationary process which was described in connection with war financing. In this case, however, it was privately rather than governmentally generated, and it was based on rising speculative profits and security prices instead of on rising wages and commodity prices. It only needed the accumulated doubt of 1929 to prick the bubble. The credit inflation which was built on unwarranted profits and investments, foundered on the failure of purchasing power for the consumer goods flowing to the market.

As to the second effect of oversaving and overinvestment, it should be clear that there must be, as suggested, a ratio between capital goods and consumer goods such that production is continuously improved in efficiency and output and necessary experimentation is financed, while at the same time the maximum of desired goods and services is provided and distributed. While the production of unusable capital goods (as of hotels, apartment houses, office buildings, and industrial capacity in 1927, 1928, and 1929) does for the moment distribute purchasing power, it is obviously a process which cannot continue into a state of large unbalance. Not only is such a state fatal to the credit structure, as has been described, but it would produce a serious oscillation of business even if the expansion was financed from savings alone.

We were not stopped in 1929 by absolute overproduction. The scale of material production, consumption, and enjoyment which we experienced in 1929 is one which we may again attain, attain with safety, and with safety surpass.

There are but two logical limitations to the scale of output: a flood of goods too great to be rationally enjoyed, or one which unduly exhausts our resources.

As to the first, there can be no question if we view the state of our population as a whole. At no time has the great mass of those able and willing to work been adequately housed or properly clothed and fed; nor has it had in abundance the means of rational enjoyment. The hope of industry for a prosperous future lies in filling these unfilled needs.

But were we exhausting our resources? Certainly not in the sense of drawing on goods which we ourselves or our ancestors had laid by in store. What we consumed

and enjoyed we ourselves concurrently made, and what we made we had a right to enjoy. As to the exhaustion of irreplacable natural resources, that is for the moment an academic question, in view of the fact that an unprecedented access of natural wealth was one of the factors contributory to the debacle.

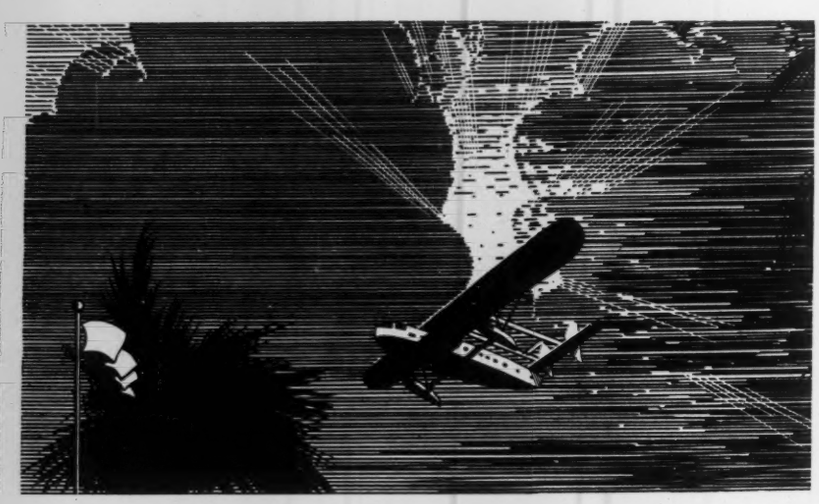
The New Era of 1929 was solid in its possibilities, though false in its foundations. Those foundations were built out of crumbling credit, and were laid upon insufficient purchasing power. Hence the instability of the scale of living attained, and its failure to improve as it should.

No argument or explanation is needed for the thesis that disproportionate and unneeded saving and investment interfere with the proper distribution of purchasing power. It is in itself an improper distribution.

Inherent Instability

Inherent instability of structure of our mechanized civilization intensifies the damage resulting from those destructive oscillations, some of whose causes have been described. An incomplete list of these instabilities follows:

There is, first, the shift from subsistence to staple agriculture which takes place as transportation is improved and world-wide commerce is developed. Subsistence agriculture is the most stable of all occupations, being dependent only on the vagaries of the weather. It is, however, one which maintains only a low scale of living. Staple agriculture, as of cotton or wheat, promises greater returns, but is dependent on national or international business conditions whose variations are far more serious than those of the weather.



A second factor is the shift from subsistence agriculture to urban industry—again an advance to a higher plane of living while business is good, but disastrous when the bottom drops out.

A third unsettling movement is the shift from the manufacture of the staples of existence to the industries producing accessories and luxuries. Again we have an advance in the scale, but one which can be held with difficulty, since the slightest business recession disproportionately reduces employment in these less necessary occupations.

A fourth unstable element is the increasing importance of the capital-goods industries, which produce manufacturing equipment, engineering structures, etc. These again cease to function during a depression and recover but slowly, with corresponding distress to their employees. There is no need to dwell on this point if the reader is a builder of machine tools or locomotives, for instance.

Lastly, there is a steady flow from productive occupations in general to sales and service occupations of various sorts. These latter are characteristic of a more developed civilization, and are in great part desirable in themselves, but they are subjected to drastic reduction as business falls off.

These elements (and others not mentioned[7]) are probably far more valid and effective than the much-discussed factor of technological unemployment. Popular theory requires that such unemployment should have been increasingly evident even during good business; yet reputable statisticians have been unable to verify this contention. It would appear that *instability* of employment, rather than its decrease in volume in good times, is the dubious fruit of our technological tree.

II—AN IDEAL OPERATION OF OUR ECONOMIC SYSTEM

We have outlined a sufficiently complex statement of the causes of our economic unbalance. As a statement, it is probably incomplete and certainly controversial. Yet it is sufficiently free from superficiality to warrant its use as a basis for constructing an ideal program for operating our profit economy in ways which will more successfully steady, raise, and distribute the services and material goods whose abundance constitutes our scale of living. Five radical changes in our present practise are suggested.

(1) If we are to have wars in the future, some basis other than credit inflation must be found for financing them. There is no physical necessity for the generation of funds in excess of the production of materials and munitions. A drafting of capital, of labor, of management, of natural resources, and of profits, as we did with the more precious human lives, would permit the waging of a war which is paid for day by day.

Thus the scale of living for the period of the warfare will be lowered as is inevitable. But we shall escape the long-drawn-out miseries of war deflation, with its burden of indebtedness and its succeeding generation-long period of business bankruptcy and social disintegration.

It only needs the deep-seated conviction of the eternal rightness of the conflict in the hearts of the people to wage war on such terms. We should sacrifice our property, our profits, and our lives on conviction of such strength and depth. It will be an eternal disgrace if we ever allow ourselves again to be led into a conflict which so lacks these convictions as to need the shameful stimulant of credit inflation, rising prices, and personal profit to marshal our men and our munitions on the battle front.

(2) Ordinary commercial credit (30-, 60-, and 90-day notes) must be confined to financing current operations. It is the characteristic of credit extension of this type that both in volume and velocity it tends to equate itself with the flow of goods to market. It therefore does not seriously affect the price level. Furthermore, being of "self-liquidating" type, it does not build up a long-term body of indebtedness, which consumes current purchasing power when extinguished by repayment under later and differing price and income levels. In short, credit of this type, properly extended, provides purchasing power in the amount and at the time needed.

About four-fifths of our active monetary supply is bank-credit money thus generated, the remainder being gold, or currency for the most part gold-based. If this four-fifths can be steadied in its operations by this policy, there will be far less criticism of the gold basis than exists at the present time; and we may yet retain the advantages of gold in a normalized international exchange. As matters now stand, it is not gold but credit, its hysterical partner, which causes more than four-fifths of the trouble.

[7] See, for instance, the author's paper on "The Economics of Machine Production," MECHANICAL ENGINEERING, September, 1932, for additional factors depending on high fixed charges.

(3) Physical investment must be financed out of savings, not out of credit inflation, except as an emergency process pending the organization of savings for the purpose.

In the final account, there *is* no other way to finance investment. The funds saved out of consumption are the financial counterpart of the materials and labor diverted from the provision of consumption goods to the provision of capital goods.

Any severe deflation, certainly this one, reveals a mass of long-term investment, in actual physical goods or as represented by stocks, bonds, and mortgages, which were financed by credit expansion.

The damage in this is twofold. Being an artificial provision of funds, not based on the production of goods, it raises the price level in the investment area to which it is applied and generates speculation and further credit inflation as we have seen. This leaves the typical high-income debt to be paid in low-income periods. Besides, this is the added aspect of a mass of nominally liquid assets which are in fact frozen by deflation, producing disastrous results with which we are only too familiar.

Confining credit expansion to current business operations and financing investment from savings are fundamental policies. Indeed, the proper measure of inflation is the amount of credit which has abandoned its proper uses and has been applied to long-term commitments of the investment type. This, and this only, is inflation, and the amount of it is preferably kept as near zero as possible.[8]

(4) A reasonable balance between spending and saving must be maintained.

There is a strong probability that the control of inflation which would result from adopting the two preceding policies would favorably affect this factor also. If the disruptive effects of inflation are controlled, it seems probable that the interest rate would perform its normal function of governing the ratio between consumption and investment. It would probably tend to approach that 3 or 4 per cent which Carl Snyder has calculated as being the average actual increment in wealth in this country over a long period of time.

As to that illusory form of investment which consists in bidding up existing securities, or in floating issues which do not represent physical investment, these operations and their resulting oscillations can be damped by rules requiring larger margins, or by substantial Federal stock-transfer taxes. These could be set to restrain speculation without handicapping investment.

There is the final resource of taxation to redistribute large incomes from unneeded investment into desirable social expenditure. This may be done as Dr. Dickinson suggests, by a tax on increase in capital value; or better, I believe, as Mr. Coyle, Dr. Jordan, and others have suggested, by a properly designed general income tax. In any event, it is probable that we shall want, as time goes on, to spend an ever larger share of our total income socially rather than individually. The highest human values will be served thereby.

(5) There is a wide range of minor policies which may be adopted to meet various elements of instability which have been described; as, for instance, the physical decentralization of industry, with a corresponding development of subsistence gardens, etc.

The facts remain, however, that these policies are all palliatives, however desirable; that the instabilities are inherent in a civilization which is in itself full of unrealized possibilities to a greater extent than any other of which we know or can conceive; and that we shall therefore work more wisely in controlling the disruptive forces than in attempting to give rigidity to a vital, developing structure.

These are only five of the possible lines of adaptation of our system to the incidents and accidents which seek to destroy it or to render it useless as an instrument of human welfare. Each was only briefly sketched, and there are many more which are almost as hopeful.

III—THE NRA AND OUR ECONOMIC ORDER

If all, or any considerable portion, of the considerations set forth have a reasonable validity, we are rightly astonished at the variance between the picture which they present and that which furnishes the background for our present effort at recovery. Our analysis calls for reforms principally in financial practise, partly in governmental fiscal policy, and only to a minor degree in industrial and commercial procedure. Yet NRA policies are focused on industry as the key element in recovery. This discrepancy is so radical that we may well conclude with a few moments of analysis of our national recovery program.

The following are among the elements which it would seem consistent to accept as permanent policy:

SHORTER HOURS

While there is nothing in the causes of our present

[8] This important analysis is clearly described, and an inflation index based upon it is presented in E. C. Harwood's book, "Cause and Control of the Business Cycle."

situation which gives to shorter hours fundamental curative effect, the policy does have its uses in distributing work during recovery; and it may be properly accepted as an overdue social dividend on the operation of our labor-saving machinery. If at this time we cannot in 35 or 40 hours a week make all that we wish to consume, then our improved mechanisms are not what we claim them to be. As a matter of fact, if we can arrange by proper means to keep men working 35 hours a week year in and year out, instead of shutting them down for the months or years of hard times, we will be adding to their productiveness instead of subtracting from it.

AGE LIMIT AND MINIMUM WAGE

The raised age limit (elimination of child labor) is a matter of human decency which we can all accept. The minimum wage, properly set, comes in the same category.

SALES BELOW COST

The prohibition of sales below cost, except in carefully regulated exceptions for liquidation purposes, is a step which may tend to reduce the violence of business fluctuations, and will certainly work out to the best good of all in our day-by-day business relations.

Elimination of abuses in general of the types peculiar to the individual trades should be accomplished for the same reasons as the prohibition of selling below cost.

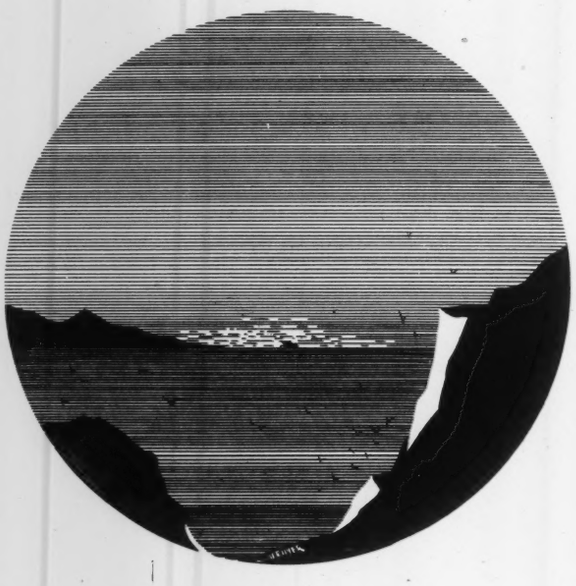
The elements of which we should beware are numerous. In general they are of the type which will inevitably lead to an increased power and activity of the Government in our private business policies without any corresponding gain to society as a whole, as judged by our analysis. The following are among the dangerous tendencies which some enthusiasts are endeavoring to fix upon industry:

LIMITATIONS ON THE USE OF MACHINES

Having declared a dividend of leisure in shortening the working week, continued improvement of machines and continued extension of their use are the means by which society may expect to rise to a higher standard of living. This is so obvious that it is indeed strange to find it questioned at all.

PRICE SETTING

Price setting is another seductive, but dangerous, possibility in the new legislation. Price setting will inevitably lead to governmental control of many sorts and of undesirable degree. The greatest danger lies here.



Allocation of output and of territories, except for certain natural resources, is likewise a dangerous process. It appeals particularly to the large established industries who wish to hold their present gains with as little effort as possible and are willing, if permitted to do that, to submit to an increased measure of governmental control. In this matter, established and matured firms are ranged against the vital and developing ones to the disadvantage of society as a whole. It is doubtful if even these established firms would complacently accept governmental control if they could see the end from the beginning.

RESPONSIBILITY

And finally we must beware of the acceptance on the part of industry of anything like full responsibility for the sum total of economic evils. This full responsibility must be disavowed vigorously and unremittingly, while we continue with willingness to accept such responsibility as does belong to us. That we should continuously call attention to the major evils which lie within the areas of government and financial activity is a public duty. Otherwise, those evils will fail of their proper attention and we shall be launched on an era of minute governmental control of business from which no good can come and from which we may never escape.

In conclusion, the whole of this analysis casts doubt on the necessity for discarding incontinently the institutions which have brought us to the hopeful position we occupy today. The required sections are seen to be of a type which frees our system from disturbing forces, as opposed to policies which would force it by herculean and endless effort into predetermined molds. The unnatural strain of the effort we are making is already only too apparent.

It is worth while that there should be made this high-hearted experiment of a purposeful recovery, based directly and humanely on a revival of mass purchasing power instead of indirectly on a revival of profit. There is reason to hope that it will succeed. But there is no hope that the normal development of business and the longed-for improvements in the scale of living for the masses can be attained by an indefinite continuance of this tension of detailed control.

Let us rather, as recovery becomes a fact, liquidate this heroic effort into a simpler and gentler reliance on age-old social forces, but with these forces more wisely controlled, more humbly accepted. Only so can we hope to build a future more nearly to the plan of our highest aspirations.

MEASURING OUR CAPABILITIES

Human Engineering Laboratories Are Striving to Find the Work to Which Men Are Best Suited and in Which They Have the Greatest Chances for Success

By CLARENCE W. SQUIER[1]

MANY phases of our lives, which, until recently, have been charted obscurely, are now receiving the benefits of newly found and carefully developed methods. Among these is the science of vocational analysis, which has for its object the finding of the right job for an individual and the directing of young men and women into courses of study where they can use their abilities to the best advantage. By numerous tests which psychologists have developed for this purpose, the aptitudes and abilities of men and women can be determined with surprising accuracy. When the aptitudes of a person are known, proper advice and guidance can be given as to a career that will make most use of them. This is what the Human Engineering Laboratories at Stevens Institute of Technology, Hoboken, N. J., and at Boston, Mass., are now doing.

Young people about to choose a college or a course of study leading to a profession or career need to know their aptitudes. Otherwise, they may make an unwise choice and spend several years studying for a particular occupation in which they cannot succeed. Sometimes they fail in college while taking a course for which they have no aptitude. With proper knowledge as to their abilities, they can change to another course or to another school in which they are better qualified to succeed. Many schools are applying these analytical methods to exceptional cases, to boys and girls who are especially outstanding as well as to one-sided and backward children. In these laboratories any normal boy or girl can have full benefit of modern research findings.

Many industries are also using these measures as an aid in placing an applicant at a type of work for which he or she is best fitted, sometimes in transferring an employee from one position to another, sometimes as a guide in reassigning a worker who is failing. A distinct failure can often be turned into success by transfer to carefully selected work. Sometimes men and women work hard at a vocation and after several years are forced to realize that they are not fitted for that type of work. What else can they try with greater assurance of success? The try-and-fail method of finding an answer to this problem is long and discouraging. These persons need help to get started in their life work.

[1] Huntington, N. Y. For the past year and a half Mr. Squier has been associated with Johnson O'Connor, Associate Professor and Director of Psychological Studies, Stevens Institute of Technology, Assistant Professor of Business and Engineering Administration, Massachusetts Institute of Technology, and Director of The Human Engineering Laboratories at Stevens Institute and at Boston, Mass.

THE APTITUDES THAT ARE MEASURED

In the various research studies and analyses made in the Human Engineering Laboratories, seven distinct aptitudes have been isolated and can be measured, two others can be approximated, and some evidence of the existence of six additional ones has been obtained. The seven aptitudes or mental elements which can be measured most accurately are:

(1) *Personality*. The distinction between the objective, sales, executive type, and the subjective professional, research, and designing engineering type.

(2) *Tonal Memory*. A gift for carrying in mind musical themes which have been heard. It is interesting because there is a slight relationship between tonal memory and vocabulary, the better the tonal memory, the larger the number of words which an individual remembers.

(3) *Engineering Aptitude*. A gift for visualizing three-dimensional structure, fundamental to success in engineering, architecture, surgery, and the higher types of mechanical work.

(4) *Accounting Aptitude*. A gift for grasping the significance of figures fundamental to success in accounting, banking, and all clerical activities, including those involved in doing the more routine parts of school work.

(5) *Tweezer Dexterity*. A type possessed by surgeons and by miniature-instrument assemblers. Some would not classify this as a mental element, but it is a distinct characteristic unrelated to the others.

(6) *Finger Dexterity*. This, for some odd reason, has practically no relation to tweezer dexterity. The ability to use one's fingers is distinct from the ability to use a small tool, such as a pair of tweezers.

(7) *Creative Imagination*. A characteristic which in the engineer leads to the conception of new contrivances and to obtaining patents.

Two elements which can be approximated are:

(8) *Inductive Reasoning*. A recognition of relationships, which is, probably, a characteristic of diagnosticians in medicine and perhaps of pure scientists.

(9) *Visual Memory*. A characteristic of factory production followers.

Many more which cannot, even as yet, be approximated certainly exist.

Of course, there is a variation in the number of these aptitudes which different persons possess. Only one man in about 16,000 scores in the upper 25 per cent in

the seven aptitudes just given, but one man in about 125 scores above average. Analysis of data gathered in testing a large number of major executives shows that it is impossible to say definitely in how many aptitudes successful executives score high. Individuals vary widely. Using the letters *A*, *B*, *C*, and *D* to indicate the four quarters into which groups are graded, it was found that in one group of major executives who were measured in four aptitudes, 45 per cent graded *A* in all four, whereas in an unselected group of men of the same age, only six per cent graded *A* in all four aptitudes. Not one of the executives graded *D* in all four aptitudes, whereas in an unselected group 6 per cent graded *D* in four. As a group, executives score above average, that is *A* or *B* in a majority of aptitudes.

Analysis of data gathered during many years of psychological testing indicates that the different aptitudes can be grouped and that a certain definite group can be associated with each vocation as contributing to success in that particular work. Thus, in measuring men and women who are recognized as successful executives, five characteristics have been isolated. These are:

(1) Large English vocabulary
(2) Wide range of aptitudes
(3) Objective or extremely objective personality
(4) Accounting aptitude, and
(5) Aptitude for first position.

Again, four characteristics common to men and women successful in sales work are:

(1) Extremely objective personality
(2) Creative imagination
(3) High accounting aptitude, and
(4) Low engineering aptitude.

TEST RESULTS DIVIDE ENGINEERS INTO GROUPS

From the results of tests measuring several hundred successful engineers, it has been found that they can be separated into two general classes: First, there is a class that includes designing engineers, scientific research workers, and inventors, whose individual work is an outstanding characteristic. The second class includes the group worker, the engineering executive, and engineering salesmen. One essential difference of these two classes is that of personality. The first class tests "subjective" or "extremely subjective," while the second class tests "objective" or "extremely objective." Both classes score high in engineering aptitude.

In an article "A Study of Human Nature," which appeared in the December, 1932, issue of the *Atlantic Monthly*, Johnson O'Connor discusses personality and says in part that there are two types of personality, objective and subjective. The typical extremely objective person is the hail-fellow-well-met, sales type, the group worker; the extremely subjective person is the individualist; he is quieter, more retiring, more nearly the individual worker. The two types are not sharply divided; there is no gap between them. Individuals scatter over the entire length of the scale from the extremely objective to the extremely subjective.

One hundred successful house-to-house commission salesmen who were measured scattered widely as individuals, but clustered enough at the objective end of the scale so that as a group they averaged extremely objective. One hundred business executives, presidents and vice-presidents of successful companies, managers, and superintendents, again scattered widely as individuals, but averaged objective, not so extreme as the sales group, but on the objective side. Designing engineers and the professional groups, doctors and lawyers, average subjective. Pure scientists, laboratory and research workers average extremely subjective. This is the order in which these groups, by the nature of their work, are forced to come in contact with people. The success of the salesman depends upon his meeting other men, talking with them, making new acquaintances. The duties of the executive throw him in constant contact with other persons, but not to the extent of the salesman. The designing engineer today more than ever before must meet other men successfully and yet despite this he puts in many hours of individual work for every hour he spends with others. The research worker, the pure scientist, can close the door of his laboratory in the morning and see no one during the day.

The subjective young man often does a successful sales job because of his youthful energy and enthusiasm, but as he grows older he does not find himself in an increasingly congenial atmosphere. As the years go by, he finds it more difficult to supply the energy which the subjective man must exert to be in perpetual contact with others. As the subjective man matures, he should find himself in a position of recognized authority in some field. One who is subjective should select law, medicine, designing engineering, scientific research, or individual creative work of some nature. When a student, the subjective person should get as sound a technical training as possible in the subjects which interest him, in order that he may have sufficient knowledge to express his opinion with force and conviction, and take pleasure in his accomplishments.

CHANGE IN PERSONALITY

A question often asked is: Can the subjective person become objective by forcing himself into a sales position? Attitude toward life seems to be deeply ingrained in one's essential nature, an integral part of the complexity which we call personality, and already fixed early in the teens.

With one group of normal persons, personality tests were readministered at the end of two years and comparatively little change was found, not enough to suggest that this attitude toward life is an acquired characteristic affected by environment. From the work done thus far it seems best, if one is to meet life successfully, not to try to change one's personality. Neither the subjective nor the objective personality is better than the other. Each has its own "bailiwick," its own function in life. It is when one of the individuals attempts to assume the characteristics of the other that difficulties begin.

CHARACTERISTICS OF INDIVIDUAL-WORKER CLASS

The individual-worker class, which includes designing and development engineers, research workers, and inventors, has two characteristics which distinguish it from others and three which differentiate the several groups from one another. Common characteristics are:

(1) Engineering aptitude.
(2) Subjective personality.

Three characteristics which separate the groups from one another are:

(3) Creative imagination, a trait in which inventors and designing engineers doing creative work measure high.
(4) Inductive reasoning, possessed by scientific research workers seeking general laws and called upon to recognize relationships between independently derived results.
(5) Tweezer dexterity, a characteristic of laboratory research workers, such as biologists and physiologists, who are continually handling delicate organisms.

A characteristic common to the most successful men in every field is:

(6) Large English vocabulary.

CHARACTERISTICS OF GROUP-WORKER CLASS

The second, or group-worker class, includes engineers who have executive duties of directing others, and executives of manufacturing and public-service companies. Six measurable characteristics are found commonly in successful executive engineers of this class. These characteristics are:

(1) Engineering aptitude, which distinguishes the engineer rather than the executive, but is common to executives in manufacturing and engineering organizations.
(2) Objective or extremely objective personality, which is in contrast to the subjective, retiring, research, personality which characterizes designing engineers.
(3) Many aptitudes.
(4) Accounting aptitude, which is a gift for grasping quickly and easily the significance of figures.
(5) Large English vocabulary, which is acquired knowledge, in most instances the direct result of formal schooling. It is not an aptitude in the sense in which the word is used in this article.
(6) Aptitude for first position.

These various characteristics are discussed in considerable detail in two brochures by Johnson O'Connor, "Characteristics Common to Successful Engineers," and "Characteristics Common to Executives in Manufacturing and Public-Service Companies." The following is taken largely from them.

ENGINEERING APTITUDE

Engineering aptitude is a gift for visualizing three-dimensional structure. It is a characteristic possessed by all types of engineers and by men and women outside the engineering profession whose duties require them to see in their mind's eye solid structures. It is possessed by surgeons, whose work is concrete, structural; but it is not necessarily possessed by physicians, who think in terms of symptoms and formulas. It is possessed by sculptors, but not, as a rule, by painters. It is possessed by architects, who must see a building before it is built. It is possessed by the entire engineering group, mechanical, civil, electrical, and even chemical.

Aptitudes necessary in one of these fields of engineering and not in the others have not as yet been discovered. The same gift for visualizing structure is required by all, perhaps to a slightly less extent in chemistry than by mechanical and civil engineering, but at least to some extent in all branches of the engineering profession.

USE OF ENGINEERING APTITUDE

Evidence indicates that the larger the number of aptitudes used, the happier and more successful the possessor. The gift for visualizing structure, in particular, is a dynamic characteristic which should be used. A man who scores high in this trait, but who is in work which does not utilize it, seems restless, dissatisfied, and less successful than one would expect him to be in the light of his other abilities.

There are many ways in modern life in which this gift can be used. The student who possesses it does not necessarily have to go into engineering or even into one of the sciences. He should, however, while in school and college, get the training in mathematics, in science, and in engineering which goes with the aptitude.

WOMEN IN ENGINEERING AND THE SCIENCES

Women as a group do not visualize structure to the same extent as men. Roughly, only 5 per cent of those measured score as high as the upper 25 per cent of men. Yet women who enter engineering compete with men. For this reason, the woman who uses test results as an aid in deciding whether or not to enter engineering should compare her engineering test scores with those of men. She may be high compared with other women, but low compared with men. For the woman who grades *A* in engineering aptitude as judged by men's norms, there are many opportunities in science.

CREATIVE IMAGINATION

The characteristic of creative imagination defines itself. In a group of engineers of similar experience and equal engineering aptitude, the number of patents granted each man is a crude indication of the creative imagination which each has shown in his work. Of those who grade *A* in creative imagination, four times as many possess patents as in the group who grade *D*. One who grades *A* in creative imagination and enters designing engineering has four times the chance of doing work leading to a patent as has one who grades *D*.

Furthermore, among those with patents who grade *A* in imagination, there are three times as many patents per man as among those who grade *D*. An *A* grade in the test shows the presence of something which leads to creative work in engineering.

In addition, the test has been administered to four men

who have received prizes for engineering work of marked originality. All four grade *A*. One who grades *A* in creative imagination and in other respects tests like the engineer can enter designing engineering with the hope of doing creative work in the field.

INDUCTIVE REASONING

The great scientists of the past were those who discovered general laws, who stated by a simple formula in a single sentence a relation between previously separate phenomena. The mental process involved is, as nearly as can be told from the results thus far obtained, the characteristic measured by a test for what is called "inductive reasoning."

Inductive reasoning is possessed by individuals in almost every field. One of the high scores in the test was made by a garage mechanic who, after taking the test, said: "That is exactly what I do all day. I do no repair work. My job, when a car comes in, is to take it out on the road, listen to the engine, try the brakes, and find out what is the matter."

This ability to diagnose a difficulty from a number of isolated symptoms, the ability of this garage man, is probably the same characteristic as that of the diagnostician in medicine. It is used in gathering research results and in drawing conclusions from scientific data. It is not used in experimental laboratory work, it is not used in analytical work, in the breaking down of a problem into its various aspects, but is a gift for synthesizing the results at the end.

TWEEZER DEXTERITY

Scientific laboratory workers in many fields show extreme dexterity in the handling of delicate instruments. Physiologists, biologists, and botanists use tweezers or forceps in the handling of minute organisms. Designing engineers and inventors dealing with miniature electrical instruments and with watches show the same tweezer dexterity. Young persons without this characteristic should not allow themselves to be drawn into experimental laboratory work in these fields.

ENGLISH VOCABULARY

Without a large English vocabulary, the person with an aptitude for engineering becomes a high-grade mechanic, an all-around machinist, a tool-maker or die-maker, but not an engineer, as that word has come to be used to designate a man with executive control in the engineering world. A large vocabulary more than any other characteristic which can be measured separates the successful man from the unsuccessful. It does not distinguish one type of worker from another—the engineer from the accountant, the doctor from the lawyer—but it is a mark of the successful man in every field.

LOW VOCABULARIES OF ENGINEERING GRADUATES

Engineering schools do not stress English vocabulary as do academic colleges. Although freshmen in the two types of schools score the same, engineering-college graduates average only 120 correct definitions in a list of 150, as compared with academic-college graduates who average 129. After sophomore year in an engineering college, there is practically no change in the average vocabulary of the student body. A large vocabulary is an acquired characteristic; it is within reach of any one willing to work sufficiently hard. But one whose predominant characteristic is engineering aptitude must work more consciously than need the average person, partly because language is difficult for him, partly because his education is likely to be acquired at an engineering college which will not automatically give the vocabulary he needs without some effort of his own.

HOW TO ACQUIRE VOCABULARY

English vocabulary increases as long as a young person remains in school, to the age of twenty-one or twenty-two. From this point to sixty there is comparatively little growth, less in these thirty-five or forty years than in two school years. This finding does not preclude the gaining of new words after the age of twenty-two; it shows that vocabulary does not naturally grow with experiences in life but its increase requires conscious effort.

A good rule for acquiring vocabulary is work. There are, however, several ways of progressing effectively toward the goal. One college senior, who discovered on being measured that his vocabulary was only average and not as high as that for a man of outstanding success, kept a week-by-week typed list of the definitions of new words which he encountered. When remeasured at the end of one year, he found that his vocabulary had increased as much as that of the average college student in three years, demonstrating the effectiveness of his method. In one preparatory school, boys were given lists of words and required to look up not only the definitions but the derivations. The individual cases measured before and after showed marked improvement.

Engineering aptitude can be turned from a handicap into at least a partial asset by measuring accurately a student's vocabulary once a year and allowing the engineering type to plot his own vocabulary growth.

The relationship between personality and vocabulary is U-shaped. The extremely objective and extremely subjective types have larger vocabularies than the intermediate groups nearer the dividing line between the two.

This seems to mean that while the extremely objective individual, the social type, gets words through his association with others, the extremely subjective, more retiring, individual worker gets vocabulary through reading. The college senior who increased his knowledge by keeping an exhaustive list of the words he met tested extremely subjective in personality. This is one instance of the way in which the subjective type acquires knowledge. The subjective boy probably improves about as rapidly in an atmosphere where the average vocabulary is slightly below his own as in one where it is above. Because the subjective person is easily discouraged, because, when he drops even slightly behind, he tends to draw still more into himself and not to face the fact, because he does strikingly better work in an encouraging environment, the extremely sub-

jective boy should probably be placed in a school where the average vocabulary is slightly below his own.

Because vocabulary checks more closely with outstanding success in life than any other characteristic which can be measured and because it does not normally increase after schooling, a boy or girl should remain in school as long as it is financially possible until vocabulary reaches 130 or 140 correct definitions out of a possible 150.

Whatever the means by which vocabulary comes, and there are probably many, any one who tries conscientiously can expand his vocabulary materially.

MANY APTITUDES

Major executives score high in a wide range of diverse tests. A function of the executive is to coordinate the efforts of diverse individuals. To do this successfully, he must think, reason, or visualize much as does each of his subordinates. Although he may not know double-entry bookkeeping, he must grasp the significance of figures, as does his accountant. He may not know engineering, but he must visualize as does the engineer. Therefore, to be successful, he needs a wider range of aptitudes than the average individual.

Furthermore, executives make use of every aptitude which they possess. They use a wide range in their actual vocation, but whenever they possess aptitudes such as tonal memory, which cannot be used in their daily work, they tend to use them as basis for hobbies.

As one person in four scores *A* in any one aptitude, one who uses a single aptitude is in a class that one in four can enter. As only one in sixteen scores *A* in two aptitudes, one who uses two instantly places himself in a class that only one in sixteen can gain. As only one in sixty-four scores *A* in three aptitudes, one who uses all three is in a position which many can never achieve. It is not enough to have three aptitudes. An unused aptitude might equally as well not exist.

This range of aptitudes is, as nearly as can be told from present analysis of results, an inherent, perhaps an inherited, characteristic, not acquirable, or at least not easily acquired after the ages of 14, 15, or 16.

ACCOUNTING APTITUDE

Executives, as a group, score high in accounting aptitude, either *A* or *B*. This is a characteristic possessed by bankers, accountants, bookkeepers, and clerks; and, among women, by typists, stenographers, and private secretaries. It is a gift for handling clerical details rapidly and accurately. Executives continually face the problem of making a profit. Although they may not know the details of bookkeeping, many of their decisions are based on accounting statements, and they must be able to grasp easily and instinctively the significance of an accounting statement. Accounting aptitude is, from present evidence, an aptitude in the true sense of the word, that is, an inherent characteristic, perhaps inherited, certainly fixed as early as fourteen and probably earlier, and therefore not affected by environment and experience.

Low accounting aptitude often leads to a boy's being called mentally slow. It means no more than a slowness in routine clerical work, and outside the clerical fields its lack is unimportant. As nearly as can be told from present evidence, its lack cannot be remedied; it should be recognized as a characteristic of the individual which makes him what he is. It should be met through the school years by additional time spent on home work and should be recognized in life by avoiding such occupations as bookkeeping, accounting, and banking.

APTITUDE FOR FIRST POSITION

Many who are now successful executives were fortunate enough to get as their first job a type of work which required their most outstanding aptitude and for which they were, as a consequence, preeminently fitted. When a successful executive whose outstanding characteristic is engineering aptitude is measured, it is discovered upon inquiring that he usually started at engineering or some type of mechanical work where he could use this aptitude. If his highest score is in clerical aptitude, it is found that he began with accounting or with a clerical job. The executive characteristic is probably not the aptitude for the first position, but rather a by-product of that happy coincidence, for success at the first undertaking gives a confidence, a feeling of success, which later becomes an executive characteristic.

Furthermore, starting at work which requires one's strongest aptitude, reduces the restlessness which the many-aptitude man or woman of the executive type is certain to feel. Few can obtain immediately upon graduating from college a major position which taxes every particle of ability. For many years, most must throw all of their energies into work which they feel does not require them. This is easier to do if one's primary aptitude is used than if it is constantly drawing one from daily work.

WOMEN EXECUTIVES

Women executives average significantly higher in these executive characteristics than do men executives. There are sex differences in most aptitudes. Women, as a whole, rank slightly higher than men in clerical aptitude, but are less objective. But these sex differences do not explain the high scores of women executives. This is not because women score higher in tests than men, but apparently because women who attain executive responsibilities must have more ability than men in order to gain equal recognition. With this fact in mind, the woman who has executive potentialities should endeavor to get more training than the man with whom she is likely to be compared. This may take the form of specialized training in some field, such as engineering, which can later be used as a stepping-stone to an executive position, or, it may take the form of specific executive training in a business administration course. Whatever the course chosen, a woman with executive aptitudes should prepare herself in every possible way for the executive position into which she may be drawn.

ECONOMIC LOT SIZES *in* MANUFACTURING

By PAUL T. NORTON, JR.[1]

THE EVER-INCREASING mechanization of industry has emphasized the importance of determining scientifically economic lot sizes in manufacturing. Manufacturers realize only too well that with modern production equipment, preparation costs are a larger part of total costs, and that large lots decrease the unit preparation cost. On the other hand, large lots increase the unit costs incident to storage, a fact that is too seldom given the consideration that it deserves. The purpose of this paper is to develop the theory of economic lot sizes in manufacturing in such a way that it may be used by the average manufacturing company.

The economic-lot-size formulas that have been developed up to the present time fall into two general classes. The formulas in one group are quite simple in derivation, but do not consider all of the factors which affect the problem, and for that reason are likely to give results that are far from correct. The formulas in the other group attempt to include all factors, but have the disadvantage of being very complicated. These complicated formulas may be simplified so as to give satisfactory results by omitting the factors which in any particular case are relatively unimportant, but such simplification should be undertaken only by one who understands the derivation of the general formula. No industrial manager should be willing to use a formula for determining lot sizes which he does not fully understand. The formula developed in this paper is simple enough so that it may be understood by any one, and at the same time it is thought to include all of the factors which materially affect the problem.

Before developing the formula, it is desirable to discuss the limitations of any mathematical determination of lot sizes. The results from a formula can never replace managerial skill and judgment, which will continue to be the most essential factor in the successful operation of a manufacturing plant. Mathematical investigations of economic problems consider only tangible factors, and the results so obtained must, in many cases, be more or less modified because of certain other factors which are important but which cannot be measured mathematically because of their intangible nature. Industrial concerns will never be operated successfully by cheap clerks who simply make substitutions in mathematical formulas. On the other hand, there is no doubt that an industrial executive is much more likely to make a correct decision if he has before him certain definite figures which he modifies according to his best judgment, as otherwise he must base his decision almost entirely upon guesswork.

In the formulas to be developed, let

Q = the lot size (pieces per lot)
Q_e = the economic lot size (pieces per lot)
S = total preparation cost per lot (dollars), including cost of preparing manufacturing orders, cost of setting up machines, and any other similar costs that are independent of the number of pieces in the lot
P = pieces made per day
U = pieces used per day
N = days worked per year
C = material, direct labor, and overhead per piece, dollars
A = cost of storing one piece for one year, dollars
B = taxes, insurance, etc., per cent per year on inventory
I = desired return on capital, per cent per year
V = total amount charged against each piece: (*a*) for preparation costs, including costs in production control department as well as cost of machine set-ups, (*b*) for material, direct labor, and factory overhead, and (*c*) for storage charges, including desired return on capital.

For the sake of simplicity we shall neglect the preparation cost per piece in figuring the capital tied up in inventory. We shall also assume that the total amount per piece for material, direct labor, and factory overhead C will be charged from the time that production begins. The errors due to these assumptions will be minor in most cases and it will be noted that they tend to cancel each other. After the lot size has been determined under these assumptions, it is a very simple matter to establish the relationship between the various unit costs for the lot size that has been decided upon and to adjust the lot size, although such adjustment will rarely be necessary.

It is customary in analyses of this sort to assume that the consumption rate will be uniform, in which case the average time that any piece is tied up in production and storage will be $Q/2U$ days, or $Q/2NU$ years. If the demand is markedly seasonal and the amount of capital tied up in inventory is considerable, it may be desirable to manufacture in lots of different size during different

[1] Professor of Industrial Engineering, Virginia Polytechnic Institute, Blacksburg, Va. Mem. A.S.M.E.

seasons. The proper lot size for each season may be determined by simply using the proper consumption rate.

$$\text{Unit cost for taxes, insurance, etc.} = \frac{BCQ}{2NU} \quad \ldots\ldots [1]$$

$$\text{Unit charge for return on capital} = \frac{ICQ}{2NU} \quad \ldots\ldots [2]$$

$$\text{Unit cost of storage space} = \frac{A\left(1 - \frac{U}{P}\right)Q}{NU} \quad \ldots\ldots [3]$$

It is assumed that storage space must be provided for the maximum number to be placed in storage from lot Q. The fraction of the lot that goes in storage is $(P - U)/P$. Where P is very large in comparison with U, the number for which storage must be provided is practically Q.

The total charges per piece, incident to storage, are the sum of [1], [2], and [3], and may be written

$$\left[\frac{(B + I)C + 2A\left(1 - \frac{U}{P}\right)}{2NU}\right]Q = KQ \quad \ldots\ldots [4]$$

The total charge against each piece will be

$$V = \frac{S}{Q} + C + KQ \quad \ldots\ldots [5]$$

$$\frac{dV}{dQ} = -\frac{S}{Q^2} + 0 + K \quad \ldots\ldots [6]$$

V will be a minimum when $\frac{dV}{dQ} = 0$, and therefore the lot size for minimum V may be found from the formula

$$Q_e = \sqrt{\frac{S}{K}} \quad \ldots\ldots [7]$$

This simple formula is quite similar in appearance to many economic-lot-size formulas that have been developed in the past, but as will be shown presently, it includes important factors that are ordinarily neglected.

Formula (7) may be written:

$$\frac{S}{Q_e} = KQ_e \quad \ldots\ldots [8]$$

This shows that for the economic lot size, the unit preparation charges are equal to the unit charges incident to storage. This relationship is useful in cases where it is desired to solve a problem of this sort by cut-and-try or graphical methods.

While the approximately constant unit cost of material, direct labor, and factory overhead C does not appear directly in the final formula, it does affect the economic lot size because K is a function of C.

It should be noted carefully that V does not represent the manufacturing cost per piece, because I is not simple interest on invested capital; I is the total return on invested capital that is necessary in order that this particular capital may earn its share of the profits of the business. The usual formula, which merely charges the capital invested in inventory with simple interest, may determine correctly the size of lot for minimum manufacturing cost, but it does not consider the advantage which may be obtained by turning over capital more rapidly, even though the actual manufacturing cost may be somewhat higher on account of the larger unit preparation cost with smaller than minimum cost lot size. As pointed out by F. E. Raymond, "Lot production based upon minimum-cost quantities does not conserve capital." Professor Raymond derives from the minimum-cost quantity another and smaller quantity which takes into consideration capital turnover and the proper return on capital in excess of simple interest. It would seem that for ordinary practical purposes the method outlined above will do the same thing, and have the advantage of being simple enough that the average industrial manager may understand the development of the underlying theory. Admitting that it is only through a thorough study of all factors that we may expect a complete understanding of the theory of economic lot sizes, it still seems to the author

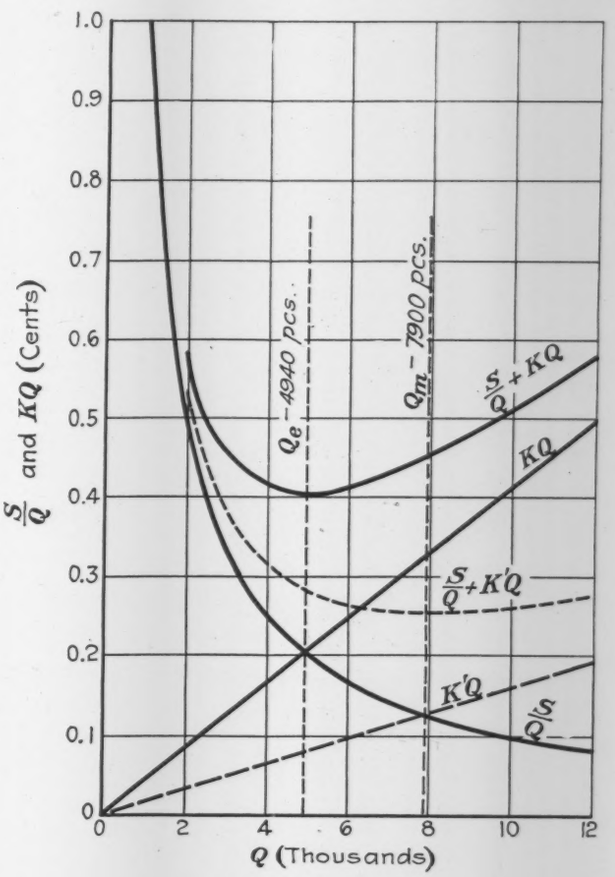


FIG. 1 EFFECT ON ECONOMIC LOT SIZE OF FIGURING, FOR A DESIRED RATE OF RETURN ON INVESTED CAPITAL, 20 PER CENT, INSTEAD OF SIMPLE INTEREST, 6 PER CENT

that it is important that a simple formula be developed, the derivation of which can easily be understood by any one, and which is sufficiently accurate for practical purposes.

EXAMPLE OF USE OF FORMULA

In order to demonstrate how the formula is used and the difference in the result obtained because the desired return on capital is used instead of simple interest, an example will be given, using the following values: $S = \$10$, $P = 1000$, $U = 100$, $N = 300$, $C = \$0.10$, $A = \$0.001$, $B = 3$ per cent, and $I = 20$ per cent. Using these values, we find that K is $\$0.41 \times 10^{-6}$. Also, the economic lot size is found to be 4940 pieces. If, however, a simple interest rate of 6 per cent were used in place of I, K would be $\$0.16 \times 10^{-6}$, and the formula would give 7900 pieces. Based on the usual method of figuring costs, this latter value would be the lot size for minimum cost, but it would be undesirable, as it would not give a sufficient rate of turnover of capital invested in inventory.

In the solution of this problem, the unit preparation cost was neglected in determining K. If the lot size is 4940 pieces, the unit preparation cost will be $\$0.002$, from which it is evident that neither K nor the economic lot size was materially affected by the omission of this item.

The curves in Fig. 1 illustrate the difference in the result obtained when the desired return on invested capital is used instead of merely simple interest. The full lines show the values of various charges when the desired return on invested capital is used, while the broken line $K'Q$ shows the costs incident to storage, using merely simple interest on invested capital. Line $S/Q + KQ$ shows the preparation and storage charges against the piece including the desired return on capital, line $S/Q + K'Q$ shows the preparation and storage charges against the piece, including merely simple interest on invested capital; Q_m is the minimum-cost lot size, Q_e is the economic lot size.

In economic-lot-size discussions, attention is rarely called to the fact that the total-cost curves are flat at their minimum points, which means that the lot size may be varied somewhat from the economic lot size without serious results. For instance, in the example given, we find the following values of V for certain values of Q:

Q	V
4000	$\$0.1042$
4500	0.1041
4940	0.1040
5500	0.1041
6000	0.1041

No attention has been paid in this discussion to reserve or emergency stock, for the reason that the economic lot size is, in general, independent of such stock.

Kodak as you go
Kodak as you go
Kodak as you go
Kodak as you go
Kodak as you go
Kodak as you go
Kodak as you go
Kodak as you go
Kodak as you go

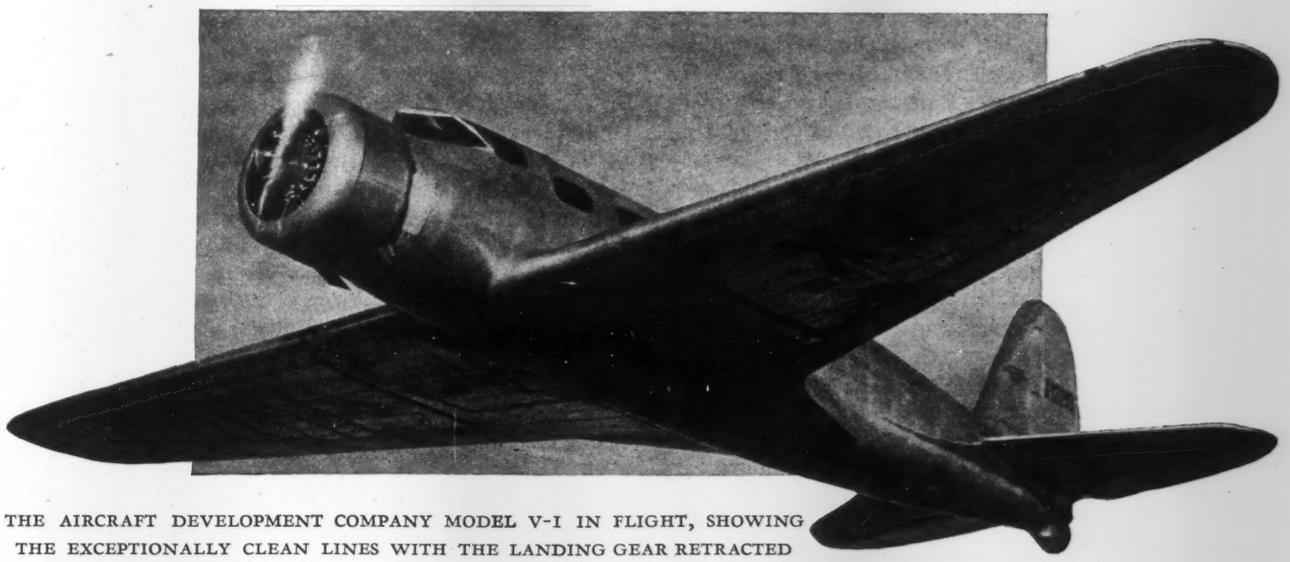
Harry Leigh Irwin

FINISHED CAMERAS ON A CONVEYER GOING TO BE PACKED. THE EASTMAN KODAK CO.

Problems in
FAST AIR-TRANSPORT DESIGN

By HALL L. HIBBARD[1]

IN 1910 the average speed of the fastest railroad trains in this country was 34.6 miles per hour. In 1920 this average dropped to 34 and in 1930 it was 40.9. Thus, over a period of twenty years, the average speed of the nation's thirty fastest trains increased 6.3 miles per hour. This rather unimpressive change in speed has been due in a large measure to the continuously increasing traffic congestion faced by all surface transportation. Increased speed has been fraught with danger. And here is one of the many advantages that air transport has over all others. Increased speeds, almost without limit, are possible with no attendant dangers and even added safety. Air transport, even during its short existence, has shown increased speeds of 30 to 50 miles per hour, and it has barely started.



THE AIRCRAFT DEVELOPMENT COMPANY MODEL V-I IN FLIGHT, SHOWING THE EXCEPTIONALLY CLEAN LINES WITH THE LANDING GEAR RETRACTED

It would be impossible in the brief space allotted to this paper to discuss all points of transport design. Therefore, a few, dealing particularly with increasing the speed of transport aircraft, have been chosen.

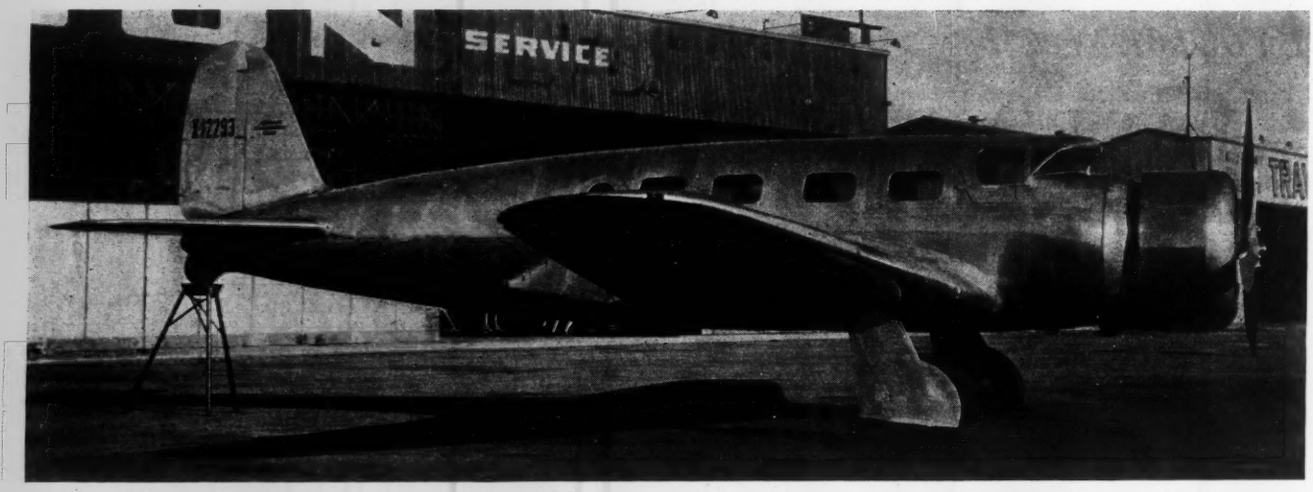
In connection with the discussion that follows, it will be of interest to have in mind a hypothetical airplane, and to note what effect certain changes have on it. Let us assume, therefore, that this hypothetical airplane has a gross weight of 7500 lb, a horsepower of 700, a wing area of 400 sq ft, a span of 50 ft, giving an aspect ratio of 6.25, a wing loading of 18.75 lb per sq ft, and a power loading of 10.70 lb per hp. Let us further assume that this is a low-wing cantilever monoplane with retractable gear, controllable-pitch propeller, but with no wing flaps.

THE PROPELLER

Before high-speed airplanes became so numerous and slow-speed planes were in vogue, aircraft propellers were fairly satisfactory. The speeds were not so high but that a propeller set at a pitch to give best performance at high speed also had satisfactory take-off and climb characteristics. On high-speed planes, however, a propeller with a fixed pitch will not have satisfactory characteristics for both take-off and high speed. One or the other must be sacrificed. The problem has become so acute that in some cases where speed could not be sacrificed the Department of Commerce requirements for take-off have limited the gross weight of the airplane. Such was the case two years ago with the first Lockheed *Orion* which was equipped with an engine without a supercharger. The take-off was so poor that even though the airplane was capable structurally of carrying a higher gross weight, this was not allowed. Of course, the propeller pitch could have been changed to secure a satisfactory take-off, but tests showed that the cruising speed was so reduced

[1] Assistant Chief Engineer, Lockheed Aircraft Corporation, Burbank, Calif.

Presented at a joint meeting, Los Angeles, Calif., July 1, 1933, of the Southern California Section of the Society of Automotive Engineers and the Los Angeles Section of The American Society of Mechanical Engineers, in connection with the National Air Races.



THE AIRCRAFT DEVELOPMENT COMPANY MODEL V-1, AN EXAMPLE OF ONE OF THE LATEST-TYPE AIR TRANSPORTS WITH RETRACTABLE GEAR

by this procedure as to make the plane uneconomical. Today, supercharged engines on the *Orion* provide emergency power for take-off, but every plane which leaves the factory with a fixed-pitch propeller has a pitch setting which sacrifices maximum cruising speed to give the proper take-off. Tests recently performed on this plane show that a loss of cruising speed of 7 miles per hour has been necessary to satisfy take-off conditions. The new Boeing two-engine transport encountered the same problem, and after the installation of controllable-pitch propellers, increased the cruising speed by 9 miles per hour. In multi-motor designs, another important factor calling for the use of controllable propellers is performance with one or more engines dead. For the new Boeing transport, the ceiling, with one engine in operation, was doubled by the use of the controllable-pitch propeller. Thus it is apparent that controllable propellers are a necessity on high-speed planes in order to provide proper take-off characteristics and still maintain maximum cruising speed. It is a common error to assume that the controllable-pitch propeller is more efficient than the fixed type on the take-off because of the change in pitch setting. Such is not the case; the fixed type is actually more efficient on the take-off, but the controllable-pitch propeller has better take-off characteristics because it permits higher engine revolutions and greater horsepower.

Given a propeller that is somewhere near the correct one, diameter, blade width, and even efficiency have less effect on performance than is generally supposed. An airplane has been tested by the N.A.C.A. with three geometrically similar metal propellers of different diameters. In each case, the pitch setting was adjusted to give the rated revolutions per minute at maximum speed. With a variation in diameter of one foot, the difference in top speed was only $^1/_2$ mile per hour.

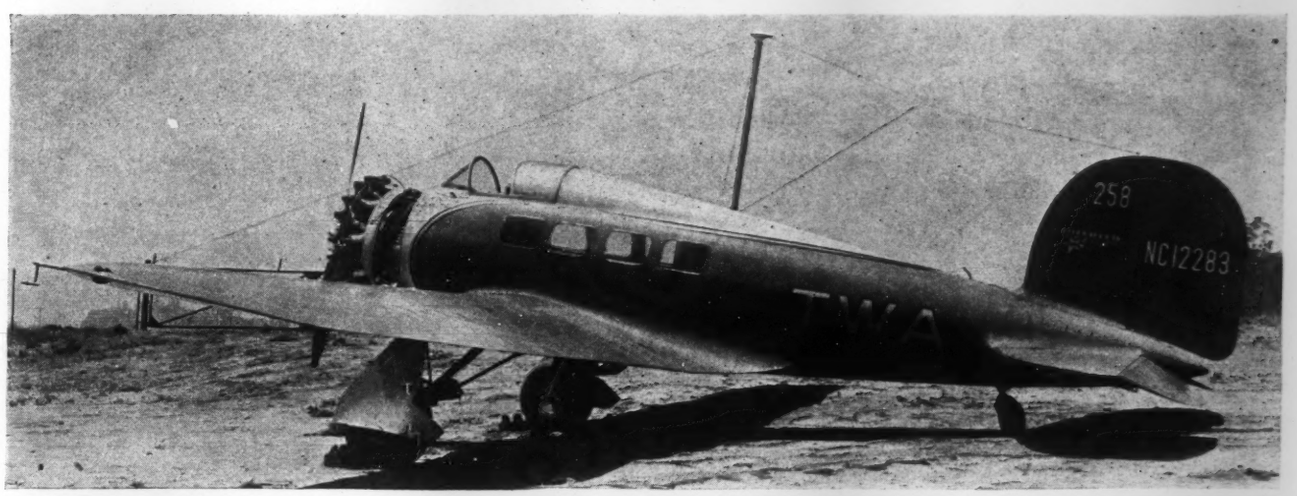
From the foregoing discussion, it will be seen that in order to provide the best cruising speed and satisfactory take-off characteristics, the propeller of the hypothetical airplane must be of the controllable-pitch type. Let us assume that the efficiency is 80 per cent, for which the computed cruising speed is 178 miles per hour. Assuming a propeller with an efficiency of 82 per cent, it is computed that the cruising speed will rise to 179.5 miles per hour. If by chance a propeller with an efficiency of 85 per cent could be found, the cruising speed would be 182 miles per hour. Thus, despite the fact that the propeller efficiency has been increased to the almost unattainable figure of 85 per cent, the cruising speed has been increased only 4 miles per hour. Obviously, there is not much to be gained in speed by increasing efficiency.

Before leaving the subject of propellers, may I state that the propulsive efficiency of pusher propeller installations is no higher than that of tractor installations. It has been said that large gains in speed could be obtained by pusher installations because of the increased propulsive efficiency. If increased speeds are obtained, British tests show that it is not due to higher propulsive efficiency.

ENGINE COWLING

One of the greatest accomplishments of the N.A.C.A. was to give the industry the cowl for the air-cooled engine. This cowl, applied to aerodynamically clean airplanes, has given an almost inconceivable increase in speed. The very first cowl of this type installed on a Lockheed increased the speed by 16 miles an hour, a record that has since been improved. But in spite of the fact that large gains have already been made, there are more yet to be made by refinements in the N.A.C.A. cowl.

Cowls must be picked with reference to the type of fuselage to which they are to be attached. If the fuselage or nacelle is approximately the same size as the engine diameter, then the cowl should extend straight back, but if the fuselage is smaller than the engine diameter, the trailing edge should be drawn in to conform to the fuselage. This was forcibly brought out by one



A LOCKHEED ORION SHOWING THE TYPE OF RADIO MAST AND ANTENNA THAT CAUSED A LOSS IN CRUISING SPEED OF APPROXIMATELY SIX MILES PER HOUR AND UNFAVORABLY AFFECTED THE LONGITUDINAL STABILITY

of the planes entered in the present air races.[2] The engine diameter was greater than that of the fuselage, and the cowl was carried straight back. Another cowl was built which was drawn in at the rear. Speed tests were run with both types of cowl and the plane was approximately 15 miles per hour faster, when fitted with the cowl drawn in at the rear. In the case of a plane with a larger fuselage, cowls extending straight back were found to be best.

The first tests completed by the N.A.C.A. indicated that a double nose section in the cowl was beneficial. Later tests, however, showed that increased speeds could be obtained by omitting this inner section of the nose cowl and changing the shape slightly. British tests and some private tests in this country have verified this conclusion, but in spite of this fact, some manufacturers still continue to use the double section which not only reduces the speed but is also more expensive.

For speed and cooling, it is not the quantity of air passing through the cowl that is important but the velocity and distribution. It is a common error to assume that blocking off the air at the nose decreases the drag. Such is not the case. Air must pass through the cowl in order to give the least drag. Tests show that the drag is higher when the nose shutters are closed than when they are open. Much is to be learned about the proper distribution of air under N.A.C.A. cowls, and further tests should be conducted along this line.

POWER PLANTS

From the point of view of the airplane designer, the engine diameter should be as small as possible. In this connection it is gratifying to note the progress that is being made along this line with all types of air-cooled engines, including the two-row radial type. Aircraft manufacturers have had the experience of substituting engines of greater horsepower and larger diameter, only to find in almost every case that the increase in speed was not what it should have been, because of the increase in frontal area.

In single-motor planes, there is but one location for the power plant, namely, in the nose of the fuselage. In multi-motor designs, if the engines are to be placed in the wings, the motors should be placed so that the propeller is located directly ahead of the leading edge of the wing by an amount equal to 25 per cent of the chord. In this connection it is of interest to note the tests which the N.A.C.A. is at present performing in connection with air-cooled versus liquid-cooled engines with radiators in nacelles. The results indicate a drag of 74 lb with the air-cooled arrangement and drags of 72 and 76 lb, respectively, with two liquid-cooled installations. This translated into cruising speed of one of the later type bimotor transports would mean the same cruising speed for either installation. This was also verified by the Army some months ago in the case of two identical bimotor low-wing bombers, one with air-cooled and the other with liquid-cooled engines. The speeds of the two were almost identical.

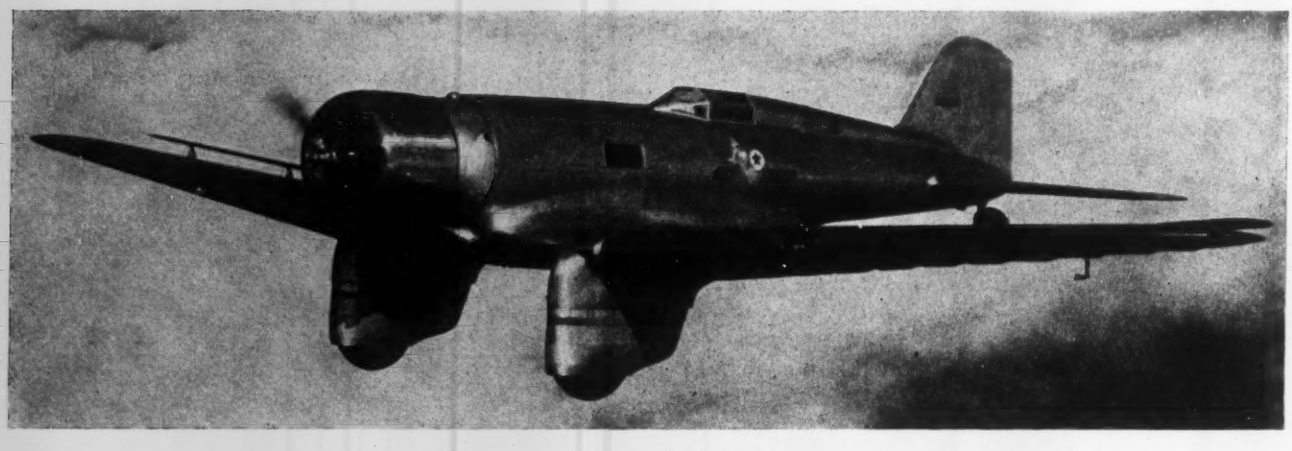
Power plants in air transports should be supercharged. Transport airplanes rarely cruise at sea level. Supercharging will give the rated power at altitude and high output in emergencies at sea level for short periods of time.

LANDING GEAR

The gain in the speed of an airplane with a retractable landing gear over one equipped with a well-streamlined gear of the non-retractable type has been greatly exaggerated. A great increase in speed because of retraction of the gear usually means that the original landing gear design was faulty. Furthermore, after retractable gears are installed, there is always the tendency to compare speeds with the gear up and down, which is obviously unfair, as retracted landing gears are never faired or streamlined and are usually quite unsightly.

Take, for example, the Lockheed *Orion*. This is the

[2] The 1933 National Air Races.



THE NORTHROP DELTA SHOWING THE NON-INTERFERENCE TYPE GEAR

original *Sirius* model equipped with a retracting gear. The major cause of drag in landing gears is interference. In the *Sirius* landing gear, all struts are nicely faired, fairings are placed over the wheels, and all joints to fuselage and wheels are well filleted. But the parts are too close together, angles are too acute, and the gear is close to the under side of the wing. The result is excessively high interference. Thus, with the retractable gear, the increase in speed was more than 25 miles per hour.

Careful wind-tunnel tests show conclusively that gears in which the interference has been removed add but little to the drag of the airplane. This type of gear is a pure cantilever type without external bracing of any kind, similar to that pioneered by Northrup. Care must be taken in the design of this gear to use a good streamline shape and it is important that the gear be carefully faired at the top into the wing or fuselage. A cantilever gear of this type will reduce the high speed of the airplane less than 6 miles per hour, which means a reduction in cruising speed of 3 to 4 miles per hour.

Thus it can be seen that there is some question as to the advisability of the retractable gear from the standpoint of speed increase. However, the retractable gear is still recommended as manufacturers will not install the non-interference type gear. They will read this article, or others, be much pleased and relieved to know that gear retraction gives such small increase in speed, and then install on the very next design the old type of landing gear with all its speed-reducing interferences.

When retractable gears first came on the market, rumors were spread about the terrible results that would surely ensue if an airplane was forced to land with the gear retracted. Up to the present, six cases are known where Lockheed planes have been forced to land with the gear retracted. In no case have there been any injuries to occupants, and in no case have more than minor damages resulted from the landing. The airplane usually slides 150 to 250 ft, depending on the condition of the ground. Because of the very high cushioning effect when the wing is only a foot or so from the ground, the landing is not rough or severe. In other words, instead of being dangerous, retractable gears have become a safety feature and transport operators are demanding them from that standpoint. It is easy to see that safer landings can be made in snow, in marsh lands, and on water; and in mountainous country landings can be made on very small patches of ground.

FUSELAGE AND ACCESSORIES

Fuselages for fast airplanes should be as small as possible, consistent with comfort. There is need for wind-tunnel data on fuselage sizes as there is little information on this subject. The British in the Schneider Trophy racers found that decrease in frontal area did more to increase the speed than any other item. On the Supermarine racer, the cross-section area was reduced from 8.46 to 5.18 sq ft, with a resulting increase in speed of 11 miles per hour. This was in spite of the fact that the resistance per square foot of cross-sectional area was higher for the plane with the smaller cross-sectional area. In a comparison of two of last year's racers, it was shown that the drag at 100 miles per hour for the one with the larger fuselage was 89.2 lb, while that for the other was 80.4 lb, notwithstanding the fact that the latter had 30 square feet additional wing area. The straight-away speeds of the two airplanes with the same horsepower were 247.3 and 277 miles per hour, respectively. It would appear then that there is a limit to fuselage size, and from most indications, the smaller the faster.

Another factor which should be taken into account in fuselage design and which has not been given enough consideration is the shape of the fuselage across the wing. Any element, even a flat sheet, placed vertically and parallel to the air stream will interfere with the air flow on the upper surface of a wing. There is a definite flow of air over the upper surface of cantilever wings, such as are being used on present-day transports, which should not be disturbed. It is evident that if a flat sheet affects the air flow, the modern fuselage must make a great disturbance. The fuselage should conform in some degree to the direction of air flow set up by the wing. The fuselage can easily be conceived as being constructed for an air flow which diverges considerably from

that set up by the wing. Furthermore, the fuselage will change the air flow over the wing, and the usual method of taking the angle of the wing alone for a given lift and using this angle in relation to the longitudinal axis of the fuselage is incorrect. The two must not be considered separately. The lowest drag of a streamline shape such as a fuselage is found at one position only, and it is important that at cruising speeds the longitudinal axis be in this position.

Before leaving the subject of the fuselage, I wish to mention the windshield, an element in the airplane which needs much refinement. Looking at the new fast transports which are either flying or being developed, the only feature which is not pleasing to the eye is the pilot's windshield. Almost any type of windshield used today will cause a loss in speed of 4 or 5 miles per hour.

THE WINGS

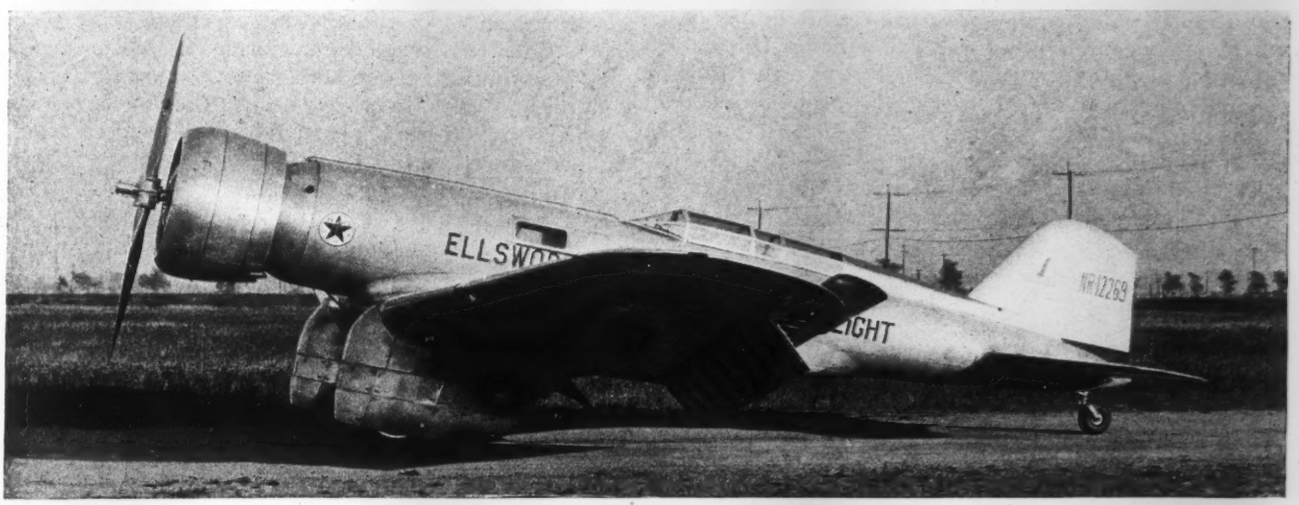
Cantilever wings are best aerodynamically and structurally if built with a taper in planiform of not less than three to one. There is no need to worry about interference between fuselages and thick cantilever wings if the proper fillets are placed between them. Wings should be given sufficient dihedral for good lateral stability. Dihedral will not affect speed up to amounts as high as ten degrees. Recently, the dihedral of a Lockheed plane was changed so as to raise the wing tips 4.5 in. Tests run before and after showed no change in speed.

The fuselage may be placed on top of the wing with the upper wing surface running continuously under it, or the upper surface of the wing may be cut away and the fuselage sunk into the recess. The former is a lighter structure; the latter a faster one. On the latest Lockheed bimotor design, 11 sq ft of frontal area was saved by cutting away the upper surface of the wing and placing the fuselage therein.

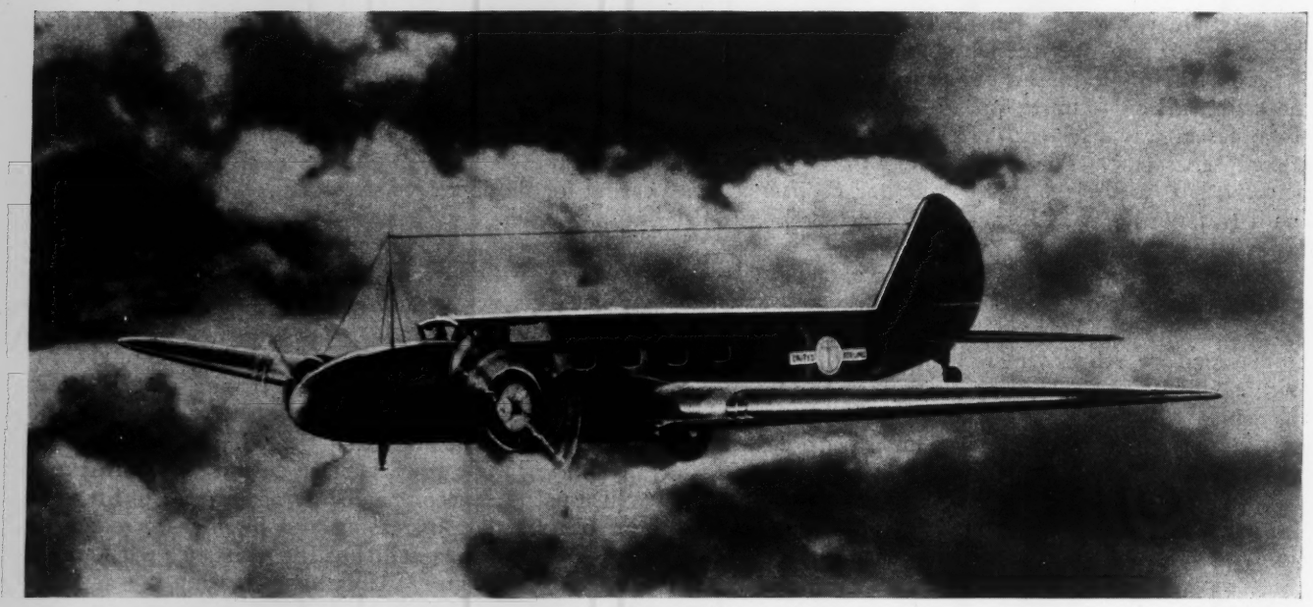
Another problem confronting the designer is that of the correct thickness of the wing at the root. There is no doubt that the thinner the wing the less the drag and hence the greater the speed. In this connection, I believe that wing weights will never be much less per square foot than they are at the present. As soon as the engineer develops a more efficient structure, he will reduce the thickness ratio of the wing at the root. Thus the advantage of the more efficient structure will be lost caring for the increased stresses developed in the thinner wing.

Thinner wings will have less drag; but recently a problem arose which yielded an interesting result. Extra volume was needed for gasoline. All available space had been used and it was necessary either to increase the wing thickness or to increase the size of the fuselage in order to find a place for the gasoline tank. Which location would result in the least increase in drag? It can be said at the start that the wing location has the advantage in one respect, since an increase in thickness will usually be accompanied by an increase in lift. On the other hand, increasing the fuselage increases the cross-sectional area and thus the resistance without any compensating factor. Upon investigation it was found that it was a question of using a 15 per cent thickness at the root of the wing and increasing the size of the fuselage or of using an 18 per cent thickness at the root and leaving the fuselage size unchanged. Computations showed that increasing the wing thickness resulted in less drag. Furthermore, the increased wing thickness gave an increase in lift. This, to be sure, was a special condition and may not apply to other designs. It was, however, interesting and instructive.

Aspect ratio has almost no effect on speed. The rate of climb is affected, but all of the new fast transports have sufficient rate of climb for the operator even with the low aspect ratios, except in very unusual cases. Low aspect ratios reduce wing stresses, result in stiffer wings, and reduce the probability of flutter. Let us investigate the difference in cruising speed of our hypothetical plane with changes in aspect ratio. The span is now 50 feet. Let us keep the area the same and make the span 60 ft. The new cruising speed is 179 miles per



THE NORTHROP DELTA SHOWING THE APPLICATION OF WING FLAPS TO THE MODERN FAST TRANSPORT



UNITED AIR LINES NEW THREE-MILE-A-MINUTE AIR LINER, THE BOEING 247, ONE OF THE WORLD'S FAST MULTI-MOTORED TRANSPORTS. IT CARRIES 10 PASSENGERS, A CREW OF THREE, AND 500 LB OF MAIL

hour. This is an increase of 1 mile per hour with an aspect ratio change of from 6.25 to 9. The change is obviously not worth while.

Speed increases with a decrease in wing area. The wing area of our hypothetical plane is 400 sq ft. Let us decrease it by 25 sq ft, keeping the aspect ratio the same. The speed increases from 178 miles cruising to 182 miles per hour. Let us reduce it 25 sq ft more; the cruising speed goes up to 186; a further reduction of 25 and it goes to 190; almost 4 miles per hour for every reduction of 25 sq ft. Now let us cut the wing area in half and we find that instead of a cruising speed of 178 we have 218 miles per hour. But in doing this the stalling speed, which was originally 69.2, has gone to 97.8 because of the new wing loading of 37.5 lb per sq ft. And here the high-lift wing flap comes to our rescue. Whereas the original wing developed a lift coefficient of 1.54, we can now install a high-lift device which will increase the lift to 3.17 and higher, more than twice that of the original wing. With this wing flap installed and deflected downward, the stalling speed has again returned to normal at 68 miles per hour.

The wing flap is one of the most important contributions to the modern airplane. Although it has been known for some time, it was not installed because it was not needed. High-speed planes with small wings and high wing loadings have brought flaps to the front, and in the future they will be used on all airplanes. Europe has come to the flap a little sooner than have we in this country. The German Messerschmidt has developed a lift coefficient in flight of 2.40.

Thus we see that by the use of wing flaps we have been able to increase the cruising speed by 40 miles per hour and still maintain the same stalling speed. With the original wing area, more than 1200 hp would be required to give the same increase in speed. At the present time, difficulties have been experienced with lateral control, but when this problem has been solved, flaps will be almost universal.

In connection with the wing, the wing-to-fuselage fillet should be mentioned. This fillet is very important from the standpoint of tail buffeting and will also decrease the drag, when properly installed. Last year Dr. A. L. Klein presented a paper[3] on this subject, and recently a report was released by the N.A.C.A. Both agree that the fillet should be small at the leading edge of the wing and large at the trailing edge.

THE EMPENNAGE

Tail surfaces should be of cantilever design without bracing. Little else can be done on tail surfaces to increase the speed of the airplane except to omit them. The drag of the complete empennage on a clean retractable-landing-gear monoplane is approximately 15 per cent of the total. In other words, if they were removed from our hypothetical plane, the cruising speed would be increased by 14 miles per hour. To remove them is impossible on the conventional plane, but this points the way to such planes as those of the tailless type, of which we may hear more in the near future.

MISCELLANEOUS

Finally, there remain several items which will be classed under miscellaneous but which are nevertheless very important. First, it goes without saying that the airplane should be covered with a smooth surface.

[3] "Effect of Fillets on Wing Fuselage Interference," by A. L. Klein, California Institute of Technology. A paper presented at the Pacific Coast Aeronautics Meeting, Berkeley, Calif., June 9 and 10, 1932, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

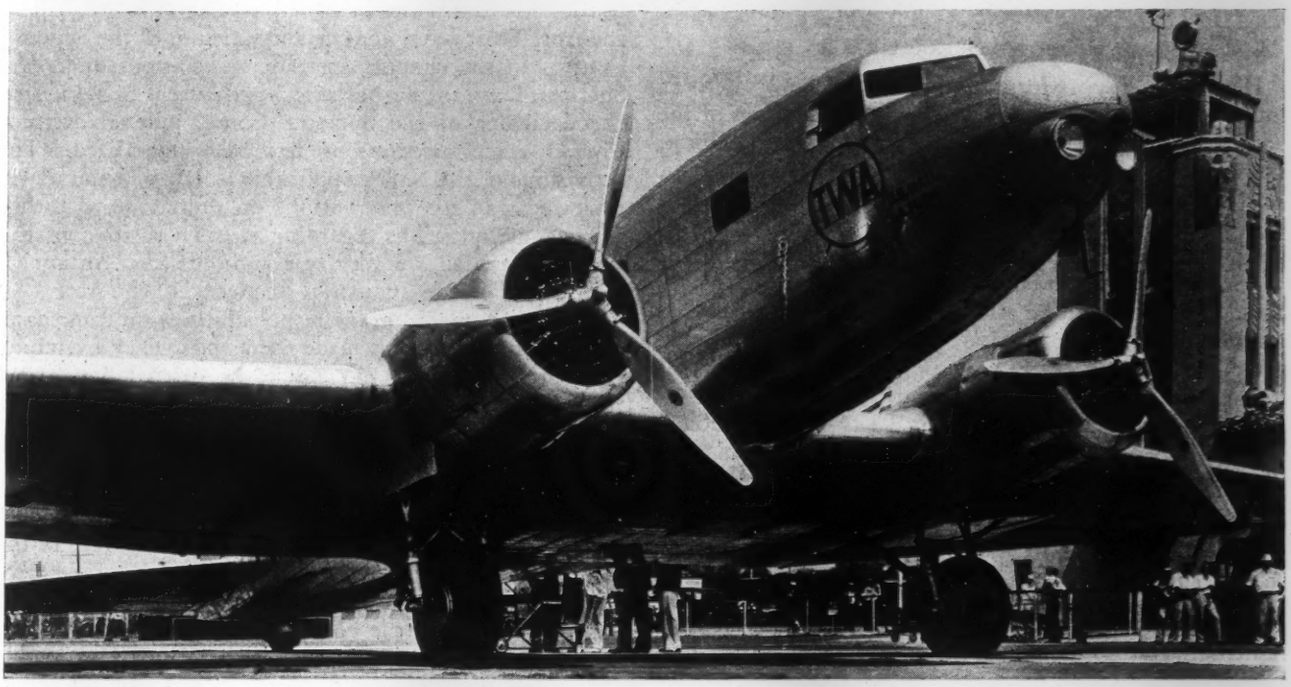
Wood and fabric are smooth, and metal, if used, should provide a smooth skin. The joints should be smooth and the rivets flush. That rivet heads do make a difference in the speed was recently proved by the N.A.C.A. The British found that protruding rivet heads on the two floats of the Schneider Cup racers caused a loss in top speed of 4 miles per hour. From the N.A.C.A. report we gather that the cruising speed of our hypothetical airplane could be increased 3 to 4 miles per hour if the rivets be made flush in the wing alone. Further improvement could reasonably be expected if the fuselage and empennage rivets were made flush.

One of the worst offenders from the standpoint of speed reduction is the radio mast and antenna. Tests were recently completed on a plane which was equipped with a long radio mast on top of the fuselage and wires extending back to the fin and to each wing tip. The loss in cruising speed due to this arrangement was nearly 6 miles per hour. This is unexcusable, and means must be found to eliminate the antenna from the air stream. Another by-product of the antenna in the slipstream was a disturbing effect on the stability of the airplane. In fact, this was so bad that the mast had to be shortened and moved forward, and even with this arrangement the stability was noticeably less than without the antenna.

If rivets make a difference in airplane speed, so do exhaust stacks, air heaters, and mufflers placed in the propeller slipstream. Heretofore, on relatively slow-speed equipment, these items made little or no difference, but on the fast clean transports they do make a difference, and tests will show that it is a surprising amount. Exhaust heating systems, mufflers, etc. must be placed inside the engine cowls to attain the highest speeds.

The last problem is the matter of weight on fast air transports. Within reasonable limits, weight has an almost negligible effect on the speed of an airplane. The transport operator of today writes his specifications for an airplane he desires and submits it to the manufacturer. He is interested primarily in three things, the useful load, the horsepower to carry that load, and the performance. He is satisfied that with this combination he can make money. The weight empty and the gross weight are, within limits, not so important to him.

In closing, let us see how two aircraft manufacturers will approach an operator wishing to buy a plane similar to our hypothetical one. The first says, "Mr. Operator, here is a transport plane with the useful load you desire. Every effort has been made to save weight, every part has been scrutinized, not a superfluous ounce can be found. The cruising speed is 178 miles per hour, service ceiling, 19,000 ft, rate of climb, 1100 ft per min, and the price is $30,000." The second manufacturer says, "Mr. Operator, here is the airplane with the useful load you desire. I have been able to save a great deal of money on this plane by deliberately increasing the weight by 250 lb. As you realize, it is those last pounds of weight saving which are costly. I have eliminated them; my plane is easy to build; all that expensive little flubdubbery, all those costly little knickknacks are gone. My airplane is robust and substantial. As for performance, the ceiling is 18,500 ft, just 500 less, the rate of climb just 65 ft per min less, and the cruising speed is just $\frac{1}{2}$ mile per hour less. I can deliver this plane to you for $20,000." Which will the operator buy?



NEW FAST TRANSPORT FOR TRANSCONTINENTAL SERVICE

(One of the Douglas machines equipped with twin engines of 700 horsepower each, having a cruising speed of 200 miles per hour. The airplane will carry fourteen passengers.)

INDUSTRY *and* GOVERNMENT

Glimpses of Recent Books Dealing With National Industrial Recovery

WRITING MORE than forty years ago, Theodor Hertzka, a Viennese economist, painted an alluring picture of human society on the beautiful and fertile Kenya plateau in equatorial Africa. He called his work, which is in narrative style, "Freeland, A Social Anticipation;" but the style was merely a sugar-coating for an unorthodox economic pill, and a device whereby objections to the scheme, which might be raised as a result of academic discussion, could be met by translating the problem into terms of everyday life.

The book ends with an admission that Freeland will be classed with Sir Thomas More's Utopia, or with Fourier's phalanges, and the Freelanders contrasted with Cabet's Icarians. But Dr. Hertzka had the advantage of such men as Fourier, Cabet, Rapp, and Owen in that Freeland existed only in the hopeful imagination of its originator and never faced the stark reality of practical test. In the closing sentences of his book, Dr. Hertzka says: "In order that Freeland may be realized as I have drawn it, nothing more is required, therefore, than a sufficient number of vigorous men. Shall I be privileged to live until these men are found?" And this wistful query, perhaps, suggests its own answer—although elsewhere in his book the author stoutly attacks the criticism that his "social anticipation" takes inadequate account of the frailties of human nature—for the world has always needed "a sufficient number of vigorous men."

PRESENT-DAY PARALLELS

Hertzka, today, is forgotten, and "Freeland" is to be found on but few library shelves, but two features of the book link our times with those of its generation. First, the author's preface might have been written today, for Hertzka was one of that rapidly growing group of persons amazed and confounded by the spectacle of overproduction and underconsumption, and inspired by the vision of what benefits are in store for human society should it be possible to strike a correct balance between production, on the one hand, and distribution and consumption on the other. Those who have seen this vision, as Mr. Flanders says, are satisfied with no other.

And the second interesting parallel is in the economic life of the Freelanders. All industrial enterprises were divided into associations in which every participant in whatever capacity was a member. It was through the mechanism of these trade associations, which were largely self-governing, that the fruits of men's labor were assured to the community with so flexible and sensitive a relationship between supply and demand that the faults of overproduction, underconsumption, and maldistribution were avoided. Happy, happy Freelanders!

The purpose of thus disturbing the skeletons of apocalyptic literature is not to seek by way of invidious comparison an approach to "New Deal" philosophy, but to emphasize the antiquity and robustness of the persistent hope that man has of rational solutions to his perplexing economic and social problems. Seldom is it permitted to men to do more with their aspirations for human governance than to write a book or establish an insignificant and short-lived colony. Yet today in the world men are undertaking these experiments in applied economics and sociology in a grand way. In Russia, in Italy, in Germany, and now in this country the accustomed relationships of human life and of citizen, industry, agriculture, commerce, and the Government are being reestablished along new and unfamiliar lines, and our prayer is that of the Viennese economist who envisaged Freeland for a sufficient number of vigorous men.

THE NATIONAL INDUSTRIAL RECOVERY ACT

Turning now to the principal object of this review, it may be remarked that books on the new deal can hardly be expected to present seasoned views of a situation which is so experimental and is changing so rapidly. Yet many of them will repay reading if for no other reason than to establish a background for better understanding. For example, Benjamin S. Kirsh[1] has prepared a brief analysis of the National Industrial Recovery Act in which he reviews the necessity for the Act and provides an explanation of it. He gives a brief summary of the important cases in which industry was affected by the Anti-Trust Laws and certain decisions of the Supreme Court. In the chapter on trade associations under the Sherman Law, the author sketches the steps by which, in the decisions of the Supreme Court, judicial attitude toward trade associations has been liberalized. The provisions of the NIRA applicable to labor are similarly reviewed. In his observations on the Act, the author raises some questions regarding it, such as its constitutionality, which are very briefly discussed. An appendix quotes Title I—Industrial Recovery, of the Act.

The NIRA placed grave responsibilities on trade associations inasmuch as it made them the agency by which the purposes of the Act might be carried out. Centralized control in the NRA with individual responsibility in the trade association were intended to remove the onus of dictatorship from the new partnership of government and industry. However this may work out practically, with final authority vested in the President and a dominating and aggressive spirit at the head of the NRA, the fact nevertheless remains that the trade association is given a task to perform that will need skill and wisdom. Already the country has been treated to numerous examples of how such associations may tackle

[1] "The National Industrial Recovery Act: An Analysis," by Benjamin S. Kirsh, in collaboration with Harold Roland Shapiro. Central Book Company, New York, 1933. Cloth, 4⅝ × 7⅛ in., 156 pp., $2.50.

grave problems. Some of these have been encouraging, others discouraging, for, as Edgar L. Heermance[2] points out, only from five to ten per cent of our 500 national associations of manufacturers may be classed as efficient.

CAN INDUSTRY GOVERN ITSELF?

Mr. Heermance views first the competitive conditions in industry that have resulted in overcapacity and says that the serious side of mechanical invention is not the displacement of labor but the increased capacity. Our troubles, therefore, are not due to the machine but to lack of management, and from this point of view the author looks at voluntary trade agreements only to find that they do not work because of competitors who do not play the game, because of treachery and suspicion, because production agreements do nothing to reduce surplus capital—overcapacity in short—and looks with suspicious eye on mergers of competitors and on cartels. Mr. Heermance considers the possibility of national economic planning and comes to the conclusion that it calls for "superhuman talent, unhampered by bureaucracy, corruption and politics," and that "a planned economy breaks down unless you can control production and price along the entire line." This leads him to question if we are not starting at the wrong end when planning is imposed from without instead of being encouraged from within and to the statement that "if regulated production is to come at all, it is likely to be worked out in the first place by business itself."

The problem being one of management, Mr. Heermance is led to consider the science of individual management, its methods—the budget, market analysis, predetermined costs—and its limitations. "Science in individual management is not enough because it will be negatived by unscientific management in the rest of the trade." Business can be brought under control only as each industrial group learns to plan together.

A SURVEY OF TRADE ASSOCIATIONS

The author is now fairly launched on his interesting and critical survey of trade associations, their many excellent features and potentialities, and the reasons they fail—trying to beat the law, the agreement complex. "I venture the strong opinion," he says, "that no trade association which breaks the present anti-combination statutes, or even hankers to do so, can ever succeed in self-regulation. If it escapes the meshes of the law, it runs into collective inefficiency..... The trade group which depends on special favors is almost certain to be inefficient."

Mr. Heermance then develops a program for trade associations which attempt to make competition intelligent rather than blind—following the market, cost finding, reporting past prices, controlling the rebate evil, credit regulation, and developing common standards. Part II deals with the very practical manner in which industry budgets are set up and operated on an industry-wide basis, and how they are extended to effect long-time planning. Part III is devoted to the obstacles to industry budgeting, (1) the speculative element in business finance, (2) the difficulty of keeping prices from sliding down to unprofitable levels, (3) the fluctuation in production connected with the fluctuation in employment, and (4) the control of the irresponsible outsider. In a chapter on "Business and the Law," Mr. Heermance foresees the increased interest of the public in business. He does not want to compel a business man to join a trade association because "the conscripted member would still be an outsider..... Injunctions and penalties would be the only way to hold him in line."

The final chapter is devoted to "The Prospect," and is a summing-up of Mr. Heermance's case for the trade association.[3] "If production is to be stabilized, it will be by applying science to business management. We have learned how to do that in individual companies. The next step is to extend scientific management to an entire trade. The industry budget system may be regarded as a goal toward which the trade associations are working..... Joint planning is a habit, slowly acquired.....given time enough, and given a solution of the credit problem, national and international, I see no reason why economic planning cannot be made to work on a voluntary basis..... The course is long and difficult, but the values of the competitive system will not have to be thrown overboard. Business need no longer drift..... With the rudder of joint planning, Management may be encouraged to take the helm."

It is fair to say that Mr. Heermance wrote his book before the days of NIRA, but it is hard to see how this detracts from his study of a promising element in industrial life—indeed, recent attempts to make trade associations function properly under the NRA bring up points that Mr. Heermance has treated in his easily read and arresting style.

THE LABOR PROBLEM

Gatherings in Washington for purposes of the codification of the industries under the NRA have found much difficulty with the labor aspects of the new Act—the famous Section 7(a). One of the annoying consequences of playing with a new deck of cards is to find that the joker has been dealt with them and with the "New Deal" this section seems to be the joker. Each interested party views it with suspicion and hopes to gain from it some class advantage. Realizing that never before has organized labor been so generously provided for and that never has the opportunity for the unionization of all industry been so propitious, labor leaders, with both feet in the trough, are pressing every advantage and diverting attention from other phases of the Act to their particular interpretation of it.

With labor in the ascendency the book by Messrs. Tead and Metcalf[4] will provide many persons with a

[2] "Can Business Govern Itself?" by Edgar L. Heermance. Harper & Brothers, New York, 1933. Cloth, 6 × 9 1/8 in., 265 pp., $3.

[3] In this connection see "The Trade Association's Part in Coordinate Planning," by E. L. Heermance, MECHANICAL ENGINEERING, February, 1933, pp. 101–104.

[4] "Labor Relations Under the Recovery Act," by Ordway Tead and Henry C. Metcalf. Whittlesey House, McGraw-Hill Book Company, Inc., New York, 1933. Cloth, 5 × 7 1/2 in., 259 pp., $2.

background against which to cast up the relative merits of the controversies arising between employer and employee. The book "aims to supply practical aid to trade associations and to employers concerning improved methods of conducting their labor relations." Principles, ways, and means of introducing some plan of employee representation, the business values and special difficulties of collective bargaining, the experiences of trade associations with labor relations, previous efforts at joint conferences on a nationwide basis, and a "consideration of efforts to make the conduct of industrial affairs square more fully and consistently with the professions of democratic purpose and the uses of democratic procedures in American life," are discussed in the book.

THE BUSINESS ASPECT

Messrs. Valenstein and Weiss[5] have turned their attention to the other side of the NRA picture, that of business. After a dolorous story of how industry was disintegrating into the demnition bow-wows, we find that it is now preparing for its rebirth. Unfair trade practises that the NRA codes are to eliminate are provided with checks and hindrances in a chapter devoted to "Industry's Forty Commandments." Several chapters devoted to merchandising problems then follow, with discussions of cartels in Germany and industrial bootlegging. Ten appendixes provide source material in the form of the Act, several Administration statements and speeches, certain codes, and "a suggested constitution and by-laws for an association under the National Industrial Recovery Act."

INDUSTRIAL DISCIPLINE

Professor Tugwell's book[6] will be read with mixed feelings by engineers as designers and custodians of production machinery and as practitioners of the art of management. They will share his belief that what we need is more machines, and not fewer; that "a gain in industrial technique is an absolute achievement." They will be flattered by some of his estimates of their abilities and functions, only to find to their chagrin that, in his opinion, their failure to measure up to their "responsibility" may be laid to the technical nature of their education, to their thinking in specific, rather than in general, terms, to the fact that they are never asked for help, and that although they have what is needed—expertness—they are using it "in such a way that it defeats its own ends." But most of all, engineers will probably be confused by Professor Tugwell's yearning for a better-ordered society which is just sufficiently suggested—just sufficiently obscure and remote—to be alluring and thus to stimulate the imaginations of those who have a penchant for social philosophies and the criticisms of skeptics. Enthusiasts for the bold experimentation of the Administration (Professor Tugwell is popularly known as one of the "brain trust") will probably understand what he means by saying that "our attitude lacks a certain welcoming experimentation," although even the boldest might have to undergo a decided adjustment of social and political views if he were literally and logically to follow the author's lead. On the other hand, one feels that present developments, as well as past actions, demonstrate the validity of Professor Tugwell's frequent allusions to the lack of far-visioned and constructive leadership in the ranks of labor.

Professor Tugwell tries to turn us from things as they are, and the past, to the future. "The generations of men are short," he says, "but they are long enough to make us conservative concerning what we value, and protective in our attitudes toward the institutions we have learned to love." But a "historic homesickness" that "tunes the affections to a half-imaginary past and persuades us toward return" may have its only cure in the "substitution of preoccupation with the future for all this contemplative leaning above the past." Engineers do look into the future, rather than the past, although it is fair to say their attention is more generally on the ground before their feet than on the distant vista. Engineers who enjoy the philosophical in "New Deal" literature will find much that is provocative and thought-provoking in Professor Tugwell's hopes for the future.

The concluding chapter of Professor Tugwell's book states the case for Government control of industry. The common purpose is security, "security of access to the goods of simple living, security of employment, security in ill health and old age, security in maintenance and training for their dependents, security in the exercise of technical tasks which involve progress in the ancient struggle to escape labor." Unregulated business enterprise having failed us, "what can Government do to furnish the kind of control which avoids instability? This the author attempts to answer by showing what Government might do in controlling the allocation of capital, prices, etc., and ends in proposing an administration of industry in transition involving a Governmental agency to classify industries, maintain a survey of consumption and production, and estimate probable markets abroad and needed products. Certificates of convenience and necessity would be issued to industrial organizations affiliated in associations authorized to set up planning boards and management devices "for maintaining standards of competition and for controlling maximum prices and minimum wages." Enough has been quoted to indicate the trend of Professor Tugwell's scheme for socializing industry. The fuller aspects must come from a reading of his book. Surely, this is "New Deal" literature.

Self-regulation, whether individual, political, or industrial, progresses haltingly. Its anticipations are idealistic and overdue, thwarted by human frailties. There is no lack of vision or of expressed objectives, but agreement, understanding, and methods of attainment are confused and fail. Whether it be Freeland, or a "New Deal," what is needed is "a sufficient number of vigorous men."—G. A. S.

[5] "Business Under the Recovery Act," by Lawrence Valenstein and E. B. Weiss. Whittlesey House, McGraw-Hill Book Company, Inc., New York, 1933. Cloth, 5 × 7½ in., 314 pp., $2.50.

[6] "The Industrial Discipline and the Governmental Arts," by Rexford G. Tugwell. Columbia University Press, New York, 1933. Cloth 6 × 9 in., 241 pp., $2.50.

The Control of
INDUSTRIAL DUST

The Problem of Local Exhaust and General Ventilation

By J. M. DALLAVALLE[1]

IT IS WELL KNOWN that the inhalation of certain industrial dusts is an important factor in causing occupational disabilities. Dust such as granite has been shown to produce a fibrosis of the lungs which is often associated with tuberculosis, while other dusts, such as asbestos, cement, slate, etc., are stated to produce a varying degree of fibrosis. In general, it has been found that dusts whose quartz content is high cause a disabling fibrosis more readily. Hence, in view of the hazards which may prevail by the inhalation of quartz-containing dusts, the problem of control is extremely important. Previous papers[2] given before this section of the Society have been concerned with the effects of exposure to industrial dusts and the methods used for their quantitation. The following paragraphs are, therefore, designed to supplement those papers and to present fundamental considerations with regard to the control of the dust hazard.

The quantity of dust produced at a given source depends upon the type of operation performed and the method used for its control. In many cases, such factors as speed of production, plant layout, and the application of dry or wet methods in certain operations have a direct bearing upon the quantity of dust generated. The effective removal of dust must consequently take into account the manner in which it is produced. In some instances, where dust is restricted to a small area, local exhaust ventilation is generally used, while in places where dusty operations are conducted on a large scale, as in foundries and batch-mixing rooms, isolation with general exhaust may be preferable. In every case, a careful study and analysis of the problem is necessary so that dust concentrations may be reduced to safe limits. Many attempts to eliminate industrial dust hazards have been unsuccessful, partly because of the lack of attention given to the principles governing the design of control equipment and partly because of failures to utilize proper methods in testing the efficiency of dust removal. The necessity of giving due consideration to these important factors is consequently clear.

[1] Assistant Sanitary Engineer, U. S. Public Health Service, Washington, D. C.

[2] "Dust in Industry," by A. E. Russell, MECHANICAL ENGINEERING, March, 1933, pp. 163–166. "Dust in Industry," by J. J. Bloomfield, *Ibid.*, April, 1933, pp. 229–233.

Contributed by the Process Industries Committee and presented at the Semi-Annual Meeting, Chicago, Ill., June 25 to July 1, 1933, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

LOCAL EXHAUST CONTROL

Local exhaust control depends upon the provision of adequate hoods and air velocities. The function of a hood is to direct an air movement of sufficient intensity to prevent the escape of dust particles and to carry them to a collecting system. This fact applies to all hoods, and although not always obvious, should be kept clearly in mind.

The problems involved in the design of hoods are many. There are few types of hoods which are designed to handle sufficient air for the elimination of dust, a condition which arises from two sources: (1) a lack of knowledge of the nature of the air flow into the hood, and (2) insufficient data pertaining to velocities necessary to set dust in motion and to bring it under control. In the following paragraphs, we shall therefore attempt to discuss the velocity characteristics of hoods and their application to the design of exhaust equipment.

HOOD VELOCITY CHARACTERISTICS

A fact little understood is that the effects of drawing in air in the vicinity of an open duct or hood differ vastly from those of blowing out the same air. In the latter case, the condition is not unlike a stream of water issuing from a nozzle; the stream is well defined and intact for a considerable distance from the opening, while in the former, no such effect is noted. This may be demonstrated by merely placing an opening under suction and noting the quickness with which the air movement diminishes as the hand is drawn outward from it. To illustrate the point further, it may be shown by actual measurement that the air velocity at a point one inch outward along the axis of a duct 4 in. in diameter is approximately one-half of what it is within the duct itself. In other words, an air velocity of 4000 fpm in the duct is reduced to 2000 fpm one-quarter of a pipe diameter outward. This rate of decrease is explained by the fact that the air is drawn from all directions. Thus, if at one of the openings we circumscribe a succession of spheres, the areas are as the squares of their radii. The velocities are then inversely proportional to the areas of the spheres; that is, as the areas increase the velocities decrease. Since the same amount of air must pass through each of the circumscribed spheres, it follows that the velocities are inversely proportional to the squares of the radii. This reasoning neglects the effect of the duct itself, but is substantially true when

the distance from the opening is very great in comparison with the duct diameter and when there is no obstruction in the field of influence. It has been found as a matter of experiment[3,4] that the velocity at any point along the axis of a hood under suction is closely given by the equation

$$\frac{Y}{100 - Y} = \frac{0.1A}{X^2} \quad \text{[1a]}$$

or

$$V = \frac{0.1AV_0}{X^2 + 0.1A} \quad \text{[1b]}$$

where Y is the percentage of the velocity at the point X along the axis in terms of the velocity at the opening

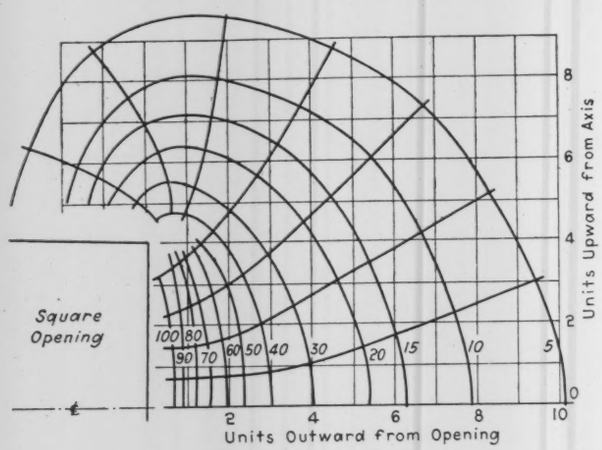


FIG. 1 CONTOUR DISTRIBUTION WITH SQUARE OPENING

V_0 and A is the area of the opening. Now at great distances, Y is small in comparison with 100 in the denominator on the left-hand side and consequently may be called zero. Equation [1a] then reduces to the form as already determined from elementary geometry; that is, Y (or V) is inversely proportional to the square of X. Hence, from the equation, it is at once possible to determine the air velocity at any point along the axis of a free and unobstructed hood, given the air flow.

Table 1 shows the variation of axial velocity with area of hood opening when the volume of air flow is kept constant at 1000 cubic feet per minute. This table illustrates the small change of velocity at great distances from the opening.

TABLE 1 VELOCITY CHANGE ALONG AXES OF HOODS OF VARIOUS SIZES WITH CONSTANT AIR FLOW OF 1000 CFM

(Determined from formula $\frac{Y}{100 - Y} = \frac{0.1A}{X^2}$)

Area of opening, sq ft	Average velocity at opening, fpm	Distance outward along axis—X— 6 in.	12 in.	18 in.	24 in.	30 in.
1	1000	286	91	43	24.4	15.9
2	500	222	83	41	23.8	15.5
4	250	154	71.5	38	22.8	15.0
6	167	107	62.5	35	21.6	14.6
8	125	95	52.5	33.1	20.8	14.2
10	100	80	50	31	20	13.8
20	50	44.5	33	23.7	16.7	12.1

VELOCITY CONTOURS

It is possible by the use of a specially constructed pitot tube[3] to map contours of equal velocity in any axial plane located in the field of influence. It has been found that the positions of these contours for any hood can be expressed as percentages of the velocity at the hood opening and are purely functions of the shape of the hood. Further, the velocity contours are identical for similar hood shapes when the hoods are reduced to the same basis of comparison. These important facts are applicable to all hood problems and from them it is possible to estimate the volume of air necessary to control a given dust source. Figs. 1 and 2 show the contour distribution in half-plane sections of two simple

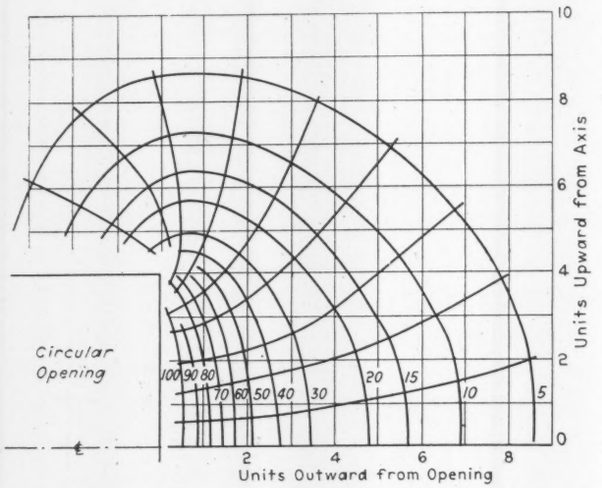


FIG. 2 CONTOUR DISTRIBUTION WITH CIRCULAR OPENING

forms of openings. The contours are typical of all hoods under suction and show the variation of velocity over the region of influence. The curves drawn perpendicular to the contours at their points of intersection are the lines of flow and give the direction of the air stream.

Hatch, Drinker, and Choate[5] have applied the methods of velocity contours to the design of hoods used on granite surfacing machines. They were enabled by a development of these contours to find the air velocities necessary to control the dust generated by these surfacing tools and to determine the rates of air flow for each type of hood. The economic advantages of several types were shown to depend upon their shapes which, as pointed out, directly influenced the contour distributions.

The development of contours for all hood types, while

[3] "Studies in the Design of Local Exhaust Hoods," by J. M. DallaValle and Theodore Hatch, Trans. A.S.M.E., vol. 54 (1932), paper no. WDI-54-10.

[4] "Velocity Characteristics of Hoods Under Suction," by J. M. DallaValle, *Heating, Piping and Air Conditioning*, vol. 4 (1932), pp. 370–375.

[5] "Control of the Silicosis Hazard in the Hard-Rock Industries." I—A laboratory study of the design of dust-control systems for use with pneumatic granite-cutting tools. By T. Hatch, P. Drinker, and S. P. Choate. *Jour. Ind. Hygiene*, vol. 12 (1930), p. 75.

valuable, often involves many difficulties. It is necessary not only to consider the shape of the hood, but also the obstructions within the zone of influence. These obstructions frequently alter the path of the air movement and distort it to such a degree as to render the hood ineffective in removing the dust. Air, like water, moves over paths offering the least resistance.

A typical obstruction often encountered is illustrated by a hood placed over a sand milling machine used in foundries. This case may be investigated by use of contours, but it is capable of a simple analysis which may frequently be applied to other hoods whose area of influence is obstructed.

When the milling machine is placed close to a hood, the air flow is almost entirely from the open sides between them. If, then, we disregard the air flowing from behind the edges of the hood, we may consider all the flow as taking place laterally inward. The open area may then be obtained approximately by multiplying the perimeter of the tank by the distance from the surface of the tank to the plane of the hood opening. We then have to measure the volume of air flow into the hood, which may be ascertained either by an anemometer placed in the throat of the hood or by means of a pitot tube. This volume of air will be the same as passes through the open sides between the hood and the mill. It follows, therefore, that

$$\text{Volume of air } Q = \text{perimeter of mill} \times \text{distance} \times \text{velocity across open sides}$$

Hence by measuring the volume of air flow into the system and by knowing the dimensions of the mill and its distance from the hood, it is possible to deduce the average velocity across the open area. This velocity determines the effectiveness of the hood in controlling the dust arising from the mill. A more exact formula[6] for determining the velocity close to the edge of the mill is given by the equation

$$Q = 1.4\,P\,d\,V$$

where Q is the air flow, P the perimeter of the mill, and d the distance between the hood opening and the mill. The factor 1.4 is a correction to take care of the uneven distribution of flow. It is assumed, of course, that the hood is of the same shape as the mill. If the hood is slightly larger, as is generally the case in practise, the formula can be used with greater assurance.

EFFICIENCY OF DUST REMOVAL

While the estimation of velocity characteristics has many inherent advantages, it is, nevertheless, necessary to supplement it with quantitative measurements of dust concentrations. In this way, it is possible to obtain correlations between air volumes and dust counts. In the study of the granite surfacing machines previously cited, Hatch and his coworkers[5] showed that the particular hoods developed by them required approximately 300 cubic feet of air per minute to reduce the dust concentration to the safe limit of 10 million particles per cubic foot. This is the dust concentration which has been found to produce no disabling fibrosis in the granite industry.[7] The same method of correlating dust counts with air volumes had been previously used by Bloomfield[8] in field studies conducted among granite plants in Vermont. It is interesting to note in this connection that Bloomfield was able to show that, under the conditions in which granite surfacing hoods were used, an air velocity of 1500 fpm at the opening was necessary to keep the exposure within a safe limit. For the particular hoods used, the air volumes handled were sufficient to maintain air velocities at the cutting tool approximating those obtained by Hatch.

The importance of quantitative measurements is further emphasized by other results obtained in an investigation of the Kelly-Hatch dust trap used in rock drilling. Since this method of dust control is not adapted to any analysis of velocity characteristics, it was necessary to determine the relation existing between the air volumes handled by the trap and the dust concentrations under varying operating conditions. In this way, it was found that a volume of 60 cfm was required to keep the dust formed to less than 3 million particles per cubic foot of air or well under the safe limit of exposure.

SUCTION STANDARDS

An important consideration entering into a discussion of local exhaust control is the present method of evaluating its performance. It is customary in most local exhaust work to express the characteristics of a given hood in terms of the suction maintained at the throat. It is important, however, to observe that suction measurements only determine the air volume through the hood, as may be seen from the equation

$$Q = 4000\,a\,f\,\sqrt{h} \qquad [2]$$

where Q = the volume of air flowing into the system, cfm
a = the area of the throat of the hood, that is, at the connecting duct, sq ft
f = a restriction factor generally equal to 0.7
h = the suction measured by a U-tube, in. of water

In Table 2 the air flows for various-sized connecting ducts are given with varying suction requirements. As is well known, these requirements differ from state to state and vary from 1.5 to 5 in. of water displacement as measured with a U-tube. One of the chief difficulties of a high suction is the losses incurred by the high air velocities in the ducts. A suction of 5 in. in any duct is equivalent to a velocity of about 6000 fpm. It is obvious, therefore, that the losses incurred are great and

[6] "The Guide." American Society of Heating & Ventilating Engineers, 1933, Chapter 37.

[7] "The Health of Workers in Dusty Trades." II—Exposure to silicosis dust (granite industry). By Albert E. Russell, R. H. Britten, L. R. Thompson, and J. J. Bloomfield. Public Health Bulletin No. 187, July, 1929.

[8] "A Study of the Efficiency of Dust-Removal Systems in Granite-Cutting Plants," by J. J. Bloomfield. Public Health Reprint No. 1324, October, 1929.

even excessive in a pipe from 2 to 4 in. in diameter, as may be seen from Table 2 which is based on duct lengths of 10 ft. It would appear, since air volume determines the effectiveness of a hood, that the most efficient way to obtain air volumes corresponding to 5 in. of suction is by using larger ducts and lower suction. Thus, if a duct 3 in. in diameter is replaced by one 5 in. in diameter, the suction requirement would be reduced from 5 to 0.65 in. for the same air flow. The saving in power would be correspondingly great. Likewise, the air velocity would be one-third as large, which would entail a further saving of energy losses. It is important to remember, however, whenever this type of reasoning is employed, that the pipe diameters are not increased so much as to nullify the conveying force of the air in the duct. The velocity should always be sufficient to carry away all the particles collected. There is rarely any need for air velocities approaching 6000 fpm. Therefore, unless it has been predetermined that a stated suction is sufficient for controlling a dust hazard, no measure of hood performance can be obtained by use of the term. If it is desired to express axial velocities in terms of suction, Equation [2] may be substituted in Equation [1b] for this purpose. Suction by itself and with no reference to the type of hood used or its location with respect to the dust source may result in serious errors.

GENERAL VENTILATION

The use of general ventilation for dust control is exceedingly complicated. The adaptability of the method depends upon a multitude of factors ranging from local conditions affecting the distribution of air movements in a building to consideration of heat losses incurred during the winter seasons. General ventilation, nevertheless, is an important factor in control where dusty sources are widely distributed as is the case in foundries, crushing and milling mills, and batch rooms. In these cases, dust exposure is general and involves large numbers of workers in non-dust-producing operations.

Courtesy Norton Company

TABLE 2 AIR FLOW CORRESPONDING TO SUCTION MEASUREMENTS IN HOODS WITH CONNECTING DUCTS OF VARIOUS DIAMETERS

Suction, in. H_2O	Duct diameter (inches) 2	3	4	5	6	7	8
1	61	137	244	381	549	748	977
2	86	194	360	540	770	1060	1380
3	106	239	424	660	950	1300	1690
4	122	274	488	762	1098	1496	1594
5	137	306	550	854	1230	1670	2180
6	150	336	600	935	1350	1840	2390

OCCUPATIONAL SURVEY

Before any attempt is made to utilize general ventilation, it is first necessary to conduct a sanitary and occupational survey. The method of making such a survey has been outlined by Bloomfield[9] and consists of an analysis of individual dusty operations. For example, in a foundry the dusting of the molds with parting compounds, sand milling, and shakeouts should be independently quantitated in terms of dust-particle-hours. Thus, if parting compounds used intermittently for a total of, say, one-half hour each day per man create 60,000,000 particles of dust, it would be said that the exposure was 30,000,000 particle-hours. The same analysis would apply to each source, and an estimate of the actual extent of dust hazards determined. The average number of particle-hours of all sources has been found by Bloomfield to check closely with the average plant dustiness.

Having conducted a sanitary and occupational survey such as has been described, the next step is to attempt to segregate or control by local exhaust methods where possible the more dangerous dust sources. There can be little benefit, for example, in exposing all the workers in a foundry to the high concentrations produced by two or three men at the shakeout dumps. The same applies to pottery workers during dry batch-mixing operations. Hence, unless some direct means of control can be applied, some effort should be made to segregate the dangerous dust sources.

Frequently, general dusty conditions can be bettered by proper housekeeping supervision. It is a peculiar characteristic of the dusty trades to neglect this matter. The care with which plants are maintained may have an important psychological effect upon workers producing dust, and may result in greater care in the performance of duties.

No specific details of the volumes required to obtain safe concentrations in a room can be given. There is need for a considerable research in this phase of the dust-control problem. At present it is sufficient to point out that quantitative measurements of dust concentrations under varying conditions of control form the most satisfactory approach to individual problems.

[9] Data to be published in Public Health Reports.

Correlation of
METAL-CUTTING DATA

By ROBERT COREY DEALE[1]

WHEN FRED W. TAYLOR presented his epoch-making paper,[2] "On the Art of Cutting Metals," he was far from thinking that he had done more than to lay a basis for further work. He believed that the really important part of his paper was to make clear to industry the possibilities of research in the field of metal cutting, to indicate methods which appeared to be basically correct, to point out methods which should be avoided, and to show some of the points which required further investigation. In the last paragraph of his paper, he declared his intention of preparing a further paper in which he expected to indicate the lines which he believed were the most important for further investigation. Unfortunately, he never presented this proposed paper.

Taylor's monumental paper has not been fully appreciated. Recent careful study has indicated that not only was the precision of the work far beyond the average of that of other work in this field, but many ideas were suggested, or actually developed, which have never become common knowledge. It has been necessary for later investigators to go back to the original paper for the basis of further work. As a result, many ideas, which at times have been new to more recent researchers, have been found to be clearly suggested in this work, although passed over by nearly all readers.

Carl G. Barth, who was associated with Mr. Taylor in this work, and who developed most of the mathematical formulas presented in it, attempted to make the data generally available through the use of slide rules. He presented a paper[3] on "Slide Rules for the Machine Shop as a Part of the Taylor System of Management" before The American Society of Mechanical Engineers in 1904, which he followed up by a paper on the same subject in the *Engineering Magazine* in 1912, and a further series of twelve articles in the same magazine in 1919. In spite of the fact that these articles gave full information as to the construction and use of his slide rules, such rules have seldom been used except in the shops where Mr. Barth or his associates introduced them. It is believed that the computations necessary for constructing these rules have seemed more involved than they really are, with the result that few engineers have attempted to design them.

When the shop production executive wishes to know just what speed and feed he should use in taking a given cut, there are no trustworthy data available in usable form. Those given in "On the Art of Cutting Metals" are based on experimental work carried on from thirty to fifty years ago, with no modern work to indicate whether or not the results achieved with Taylor's best or No. 1 steel may or may not be duplicated with present-day tool steels, such as are commercially available. Furthermore, these data comprise only the rough turning of carbon steels and cast iron, and do not apply directly to the modern alloy steels, alloy cast irons, cast steel, or the non-ferrous metals.

A METAL-CUTTING HANDBOOK PROPOSED

The American Society of Mechanical Engineers has long felt a responsibility in the field in which Taylor pioneered so effectively. Taylor's was the first truly scientific study of the cutting of metals, and the paper reporting this study was his presidential address to the Society. As a result of it, a committee was formed to study the cutting of metals and to promote the writing of papers which might lead to an extension of knowledge on the subject. Under the sponsorship of this committee, a number of papers have been presented. While the data brought out have been valuable, they have lacked coordination, and it has been difficult to make full use of them in the shop. As a result, in 1932, a Subcommittee on Metal Cutting Data, of the Special Research Committee on the Cutting of Metals, was formed, and was charged with the duty of studying existing knowledge on the cutting of metals, of coordinating these data, of filling out such gaps as were found to exist, by the necessary experimental work, and finally of preparing a series of handbooks, which should present these data in a form which could be readily used, even by a non-technical shop foreman. Such data should make it possible to predetermine the performance of a tool on any operation with an accuracy of 5 to 10 per cent.

SOURCES OF EXISTING DATA

That there already exists a rich and abundant fund of material relating to metal cutting, no one familiar with researches in this country and abroad will deny, but even a brief study of the existing data reveals the need of reducing the results of experiments to a comparable basis, and for the coordination and correlation to be undertaken by the newly formed committee.

The United States Bureau of Standards has conducted a series of experiments, but these have been primarily made to determine the effect of various alloying constituents of the tool steel, together with the most effective

---

[1] Secretary, A.S.M.E. Subcommittee on Metal-Cutting Data. Mem. A.S.M.E.

[2] Trans. A.S.M.E., vol. 28 (1907), pp. 31–350.

[3] Trans. A.S.M.E., vol. 25 (1904), pp. 49–62.

method of heat treatment. They represent the best data available on this phase of the subject, but the fact that tool bits 1/4 by 1/2 in. in section were used makes it difficult to apply the results to the larger tools generally used.

The work carried on in England under the auspices of the Manchester Society of Engineers gives valuable data on the effect of various methods of heat treatment and of various sizes and forms of tools. However, these data have the same limitations as those presented by Taylor. The tool steel used does not represent the best modern practise, while the work was done largely on the rough turning of carbon steel, although some data on the rough turning of cast iron have been presented.

E. A. Forsberg has recently completed in Sweden a series of experiments on the rough turning of two grades of cast iron and three grades of carbon steel, using three sizes of tools, having a single shape of nose. These data, which do not appear to be generally available in this country, are based on the use of modern 18–4–1 tool steels, but give information on rough turning only.

There does not appear to be any comparable set of data on any of the other operations. Such work as has been done on drilling, milling, and on the effect of lubricants has been based largely on the forces exerted on the tool under given conditions of feed, speed, and depth of cut, for the different materials. Such data as are available are not presented in a manner which permits general use, as they are scattered in a number of publications difficult to obtain. In addition, the information of value to the shop is obscured by much material of equal importance, but difficult for the practically trained man to understand. For these reasons it seems to be particularly desirable to study all available data, correlate them, fill in by means of well-planned experiments such gaps as exist, and finally, publish the results in a series of handbooks which can be used by any foreman, although it will probably be desirable to include enough of the basic theory to guide those who are capable of experimental work in adapting the results to special conditions.

AVAILABLE DATA NOT ON A COMPARABLE BASIS

Further study of the data brings out the rather surprising fact that three appreciably different methods of computing cutting speed have been used in these four sets of experiments. This fact is of importance, because it is impossible to compare directly results based on different ways of measuring speed. While this variation is not always important, the importance changes with the ratio between the depth of cut and the diameter of the log.

Taylor computed cutting speed at the large diameter of the test log, ahead of the cut. As this method of measuring the cutting speed, which is the only one that may be directly measured before the start of a cut, seems to be that customarily used in American shop practise, it is believed that it is desirable to adopt it as the basis of any further work on the cutting of metals. The Bureau of Standards has consistently measured cutting speeds at the bottom of the cut, following the tool. Both of the Manchester experiments, and those carried on in Sweden by Forsberg, were based on a speed measured midway between the bottom and the top of the cut. As this speed cannot be directly measured, it is impractical for shop use, although it is believed that it may be theoretically the most correct of the three methods.

It has been found that the method of computing cutting speed affects very materially the constants of any formula which may be set up to represent a given set of results. Entirely adequate formulas may be worked out using any of the three methods of measuring speed, but a change in method will change both exponents and coefficients of the formula. To date but a few data have been available in such a form that formulas could be calculated on the basis of all three methods of measuring speed. Such calculations as have been made, however, indicate that this effect is quite real.

An attempt has been made to determine mathematically the effect on the variables caused by variations in the size and shape of the tool used, as well as the feed and depth of cut, so as to make it possible to compare directly data which are not otherwise comparable. While the results thus far have been encouraging, much further work will be necessary before it is possible to be certain of the effect of the various elements.

It will undoubtedly be necessary to conduct a certain amount of experimental work to prove or disprove the theories which have been developed.

THE EFFECT OF TOOL SHAPE

It is noteworthy that all experimenters have confined their work to a single shape of tool, or at best similar tools, and have set up data based on the use of such tools. Taylor developed elaborate formulas giving the effect of feed and depth of cut, together with the nose radius, which represented his results with a high degree of accuracy. The Manchester results were based on the use of a given size and shape of tool, with constants showing the variations caused by changes in the size of the tool, nose radius, plan angle, and cutting angle, but it is not believed that these data are sufficiently basic to make it possible to calculate the results which might be expected from the use of a radically different form of tool. As a matter of fact, it is not believed that the data as given are sufficiently conclusive to apply to all combinations of depth of cut and feed for the general type of tool used.

Forsberg developed a formula based on the tools he himself used, which apparently applies only to the shape of tools used by him.

The only published attempt to develop a formula which may be used to calculate the results which might be obtained from any tool form is found in "A Theory and an Equation for the Life of Lathe Tools," by Ragnar Woxen.[4] While this paper is a step in the right direction, it is believed that it has not been carried as far as is desirable, with the result that it indicates a possibility rather than a final conclusion. Woxen has not recognized the fact that the various test results are on

[4] A thesis for doctor's degree presented to the Technical High School at Valhallavägen, Sweden, 1932.

different bases, and consequently may not be directly compared. He does not attempt to apply his formula to the results given in "On the Art of Cutting Metals," being content to plot these results on the basis of his method of calculation, and to show that they conform approximately to a smooth curve. This work, however, has been valuable in pointing out a new method of attack on the problem.

THE EFFECT OF THE METAL BEING CUT

It is regrettable that so few data are available on the cutting of non-ferrous metals. While steel and cast iron represent the bulk of the metals cut, the numerous copper and aluminum alloys are used in large quantities, particularly in the electrical, automotive, hardware, and valve industries, and it is highly desirable to have accurate knowledge of the best practise in cutting them. Such data as are available largely concern tool form and cutting angles, with little and very general information on permissible cutting speeds.

DATA ON DRILLING

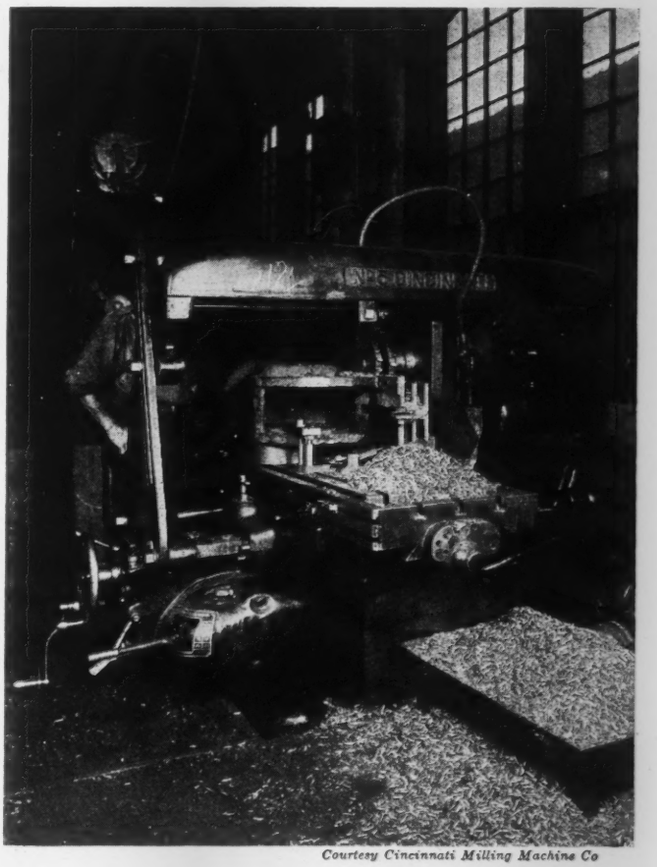
Drilling is undoubtedly the cutting operation next in importance to rough turning, but such data as are available give only recommended cutting speeds, together with a range of feeds for various materials. No information is available as to the effect of speed on tool life, while the range of feeds recommended is usually so wide as practically to leave the decision as to cutting conditions in the hands of the machine operator. As a matter of fact, it is believed that the maximum feeds recommended are smaller than should be used to secure the most efficient operation. On the other hand, only a single speed is given, when it is believed that there should be an appropriate speed for every feed. Such is the case with simple turning tools, and there is nothing to indicate that twist drills do not follow the same general law. Particularly when it is desired to set up allowed times for various jobs as a basis for a direct-labor wage incentive, is it necessary to know the speed which should be used to secure a given tool life with a given feed.

Similar data are necessary, but at present unavailable, for such operations as tapping, threading, reaming, milling, broaching, and gear cutting.

NEED FOR THE CORRELATED DATA

In the case of the production shops, where the run of any one part is long enough to make it possible to make a study of the best machining conditions for that particular part, it is possible to reach a reasonable efficiency in machining. This, however, is an inefficient method, as it is necessary to repeat the engineering investigation for each change of part, rather than to refer to basic standard data. For shops operating on a jobbing basis, this method is not applicable, as lots are generally too small to make such methods practical. In many shops, the tool forms, as well as speeds and feeds, are left to the discretion of the individual mechanics. Few shops are equipped to make scientific comparison of the various tool materials, to be sure that they are using the tools best adapted to their work and equipment, while little adequate information is available on the heat treatment of high-speed steel. Under these circumstances, there is no wonder that production in the average shop is so far below what would be possible if present equipment were used to best advantage. Such plants as have wage-incentive systems usually find it necessary to base allowed times on incomplete data, because the cost of the necessary experimental work is more than most plants can afford to pay. The result is that allowed times are irregular, sometimes giving tasks which can be completed with ease, while in other cases the tasks are impossible. The natural result is that the mechanic loses respect for the system of rate setting, and looks at it as a series of guesses—as it frequently is.

It is realized that such a program as the Subcommittee on Metal-Cutting Data contemplates involves a great amount of effort, as well as considerable expense. It can only be accomplished through the close cooperation of those who will make the savings through the use of such data—the manufacturers of tool steel and of small tools, together with all the machine shops of the country. But proper use of data such as is proposed will result in such savings in the cost of production of machine-shop products as will repay the entire cost of the project in a month's normal operation of the machine shops of the United States.



Courtesy Cincinnati Milling Machine Co

MECHANICAL ENGINEERING

Vol. 55 OCTOBER, 1933 No. 10

GEORGE A. STETSON, *Editor*

A Construction Code for Engineers

MALCOLM MUIR, Deputy Administrator of the NRA, has designated the Construction League of the United States as the agency for formulating a code for the construction industry. S. F. Voorhees, member A.S.M.E., is chairman of a committee to draft the code. A supplemental code of fair competition for the professional engineer's division of the construction industry has been drafted, and is undergoing public hearings and awaiting ratification. The supplemental code affects engineering work in connection with the construction industry only.

The American Society of Mechanical Engineers is cooperating with other professional societies, trade associations, and related groups that constitute the Construction League of the United States, having a representative on the code committee, Henry C. Meyer, Jr., of New York. It is expected that the Society, through its Executive Committee, will decide at an early date whether or not it should vote to adhere to the provisions of the code so that the Society may have a voice and be able to represent the wishes of its members in the administration of the code. The desirability of setting up a code for consulting engineers not connected with the construction industry has been under discussion but as yet no decision has been reached. Should conditions seem to warrant it, or should a sufficient demand urge it, the preparation of a code for consulting engineers should obviously be under the auspices of professional engineering societies whose leadership in such a matter should be forthcoming.

Air Transport

ON OTHER pages of this issue appears an illustrated article on fast air transports that will be an eye-opener to many whose ways of life keep them at home and in the shop and office. For it was only a relatively few years ago that the trackless air was reserved for the birds, and man could but look wistfully at creatures able to fly through unencumbered space. Oceans, rivers, mountains, and forests impeded his progress. Roads had to be built, rails laid, bridges erected, and tunnels dug if man would make his way easily over land, while by water, except on the larger expanses, his course was governed by the obstructions of coastline and the meanderings of channels. Now he takes to the air, the surface obstructions disappear, and he speeds to his destination "as the crow flies."

While a majority of engineers have been giving their talents to other tasks, a small group with vision and persistence has been pioneering in aeronautical science. As a result, such remarkable ships as those discussed by Mr. Hibbard are now being flown in regular daily service over the airways of the continent. Progress has been swift and sure—the difficulties have been real and tremendous. Air transport is firmly established.

Throughout this brief and rapidly progressing history of aeronautics, The American Society of Mechanical Engineers has attempted to lend aid and encouragement to this growing industry and has displayed and stimulated interest in the engineering and technical problems it has had to face. Professor Hibbard's paper, which was read before a joint meeting of the A.S.M.E. and the S.A.E., is evidence of that interest. It is published in order that all readers of MECHANICAL ENGINEERING may have an opportunity to learn of some of the problems which the aeronautical industry faces.

Jerome Clarke Hunsaker

THE APPOINTMENT of a head of a department in mechanical engineering in one of the largest engineering schools of the country is an event of prime importance to mechanical engineers. Therefore more than usual interest attaches to the announcement that Jerome C. Hunsaker, aeronautical engineer and Guggenheim medalist, will fill the position at Massachusetts Institute of Technology made vacant by the death of Edward F. Miller.

Commander Hunsaker is no stranger at M.I.T. As an instructor from 1912 to 1916, he established the course in Aeronautical Engineering at the Institute. Having forsaken teaching to return to the Navy to take charge of aircraft design, during which time he designed the airship *Shenandoah* and the famous NC4 flying boat, he became assistant vice-president of the Bell Telephone Laboratories in 1926, developing wire and radio services for airways, and vice-president of the Goodyear-Zeppelin Company in 1928. With his return to the teaching profession he brings a rich experience and an impressive list of achievements worthy of the distinguished office he is to fill. Commander Hunsaker was awarded the Daniel Guggenheim Medal for "contributions to the science of aerodynamics, to the science and art of aircraft design, and to the practical construction and commercial utilization of rigid airships."

It is significant of the progressive spirit of engineering that a distinguished worker in the field of aeronautics, newest of the fields in which mechanical engineers have exercised their talents, should have been chosen to fill the important post at M.I.T. While the officers of the Institute undoubtedly gave greater weight to the personal qualities and attainments of the man than to the field of work in which he has labored, friends of aeronautics will hail the appointment as a recognition of their branch of applied science and its future.

Whose Responsibility?

MR. FLANDERS, who presents a paper in this issue of MECHANICAL ENGINEERING, once more calls our attention to the dangers that lie in a failure to get at the real root of our economic troubles and protests an acceptance on the part of industry "of anything like full responsibility for the sum total of economic evils." His point is well taken and his protest worthy of an industrialist who has a lively sense of obligation toward his fellow men.

For we are beset with the very real dangers of a diagnostic failure and hence of the application of the wrong remedy, and of casting aside "reliance on age-old social forces" in favor of some untried social scheme which depends for its success on human characteristics more wished-for than real and on methods of procedure that neglect natural growth from within.

A member of the "brain trust" has written that "our problem is to liberate technique with good management," and elsewhere that "management is by no means yet a science, nor is industrial leadership altogether in the hands of people who are sufficiently intelligent to grasp the new principles of organization." Granted the saving grace of the word "altogether," such statements as "with the business man's monopoly broken, the way will lie open to reconstructive action," are likely to impress the engineer as making business and industry the goat. Imperfections in an imperfect society are not surprising, but many engineers, like Mr. Flanders, will protest at accepting an undeserved measure of responsibility, and be willing to match their hopes for the human race with the hopes of any other group.

A Cue for Engineering Schools

ADDRESSING the conference of administration officers of engineering colleges at Madison early in July, Dr. Charles R. Mann, Director, American Council on Education, expressed the opinion that popular support of higher education would return when institutions of higher learning trained people to take part intelligently in experiments with centralized control and decentralized responsibility.

This thought has special connotations in respect to engineering schools in the light of the extensive experimentation which the Administration is undertaking in such endeavors as NRA. Agreement as to the policies under which the partnership of business and Government should proceed is far from having been attained, but it is fairly generally conceded that the economic life of the country is undergoing a major and a permanent change. Industry, and hence engineering, loom large in the picture, and those under whom young men are preparing for the engineering profession have a very real responsibility to see to it that an alertness to the social, economic, and political relationships of the "partnership" is established in the minds of youth.

The best preparation for such a task is practise. The "sheltered" lives of teachers in engineering colleges must not be permitted to dull the keenness of an appreciation of what is going on in the world outside the campus. Leadership must some day rest with the men who are now receiving their technical education. They can only meet successfully the responsibilities of this leadership if they are sensitive to the needs and aspirations of industry and of society. The cue of the engineering school is to make liberal application of the principle of centralized control and decentralized responsibility. It will be a useful habit of thought and conduct for the coming years.

A Salter Text

IN A WORD," said Sir Arthur Salter in one of the Alfred Marshall lectures delivered at Cambridge University last February, "I believe that our economic system needs to develop an institutional self-discipline, aided but not in detail directed by the Government." As a first need in such a development he then placed the professionalization of organizations which at present represent sectional activities.

The philosophy is applicable to our American institutions, and has special significance at the present moment. Sir Arthur showed that such organizations as he was considering had a double aspect. The first of these he called "defensive," in that they "defended the special interests of those concerned, either as against directly opposed or competing interests or the public in general." Such an aspect pertained to the Employers' Federation as found in the coal industry, he pointed out; and transposing the conditions to our own country, we might place most trade associations and trade unions in such a category.

The second aspect was illustrated by the General Medical Council, which exists "primarily to encourage an improvement in the standards of conduct of the profession, which is in the public interest." However, he continued, "we sometimes find greater enthusiasm shown in dealing with professional misconduct which injures the profession . . . rather than that which injures the public."

Sir Arthur then points out that group organizations must be professionalized and related more directly to those who really direct action and policy if they are to become instruments of a planned economic system. But he goes on to say that "each controlling authority, if it is to have either the experience or the influence required, must be constructed from within itself and not imposed by an external power." Based on such principles, sectional planning and guiding authorities could be linked together by the formation of wider councils and culminating nationally in National Economic Councils and internationally in a World Economic Council; "so that the whole system would be an adjunct to—or rather an integral part of—the machine of Government."

It may be remarked that most safe and permanent structures are built from the ground up. Social structures should be no exception to the principle.

SURVEY OF ENGINEERING PROGRESS

A Review af Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

Some Full-Scale Experiments With Servo Rudders

SERVO RUDDERS have been fitted satisfactorily to many aircraft. To provide data for the design of servo rudders for larger aircraft and to cover the flap-type servo design, a program of tests was drawn up following a report on the general aerodynamics of servo rudders. Both types of servo were tested in the wind tunnel, the tests covering two different sizes of servo chord and various hinge positions. A report on the theory of "follow-up" in servo systems was next made.

It was then decided that flight tests on a flap-type servo rudder fitted to a large airplane were desirable in order to check the wind-tunnel tests, and these form the subject of the present report.

The cross-wind force coefficients and main rudder moments have been measured on an all-moving rudder fitted with hinged flap-type servo for a range of servo positions.

The maximum cross-wind force coefficient k_L obtainable with the rudder which was used in these experiments, and of which the aspect ratio was 2.4, is approximately 0.24 at an incidence of 14 deg. Shielding of the rudder by the tail causes a loss of rudder efficiency of 40 per cent on the calculated values. The center of pressure movement is large enough to be very important in large rudders with hinge positions set well back. The servo moments were extremely small. (J. E. Serby, from a press release of British Air Ministry, *Reports and Memoranda*, no. 1514, July 8, 1932, *d*)

Besler System of Steam Power for Aircraft

ON APRIL 12 a flight in a steam-driven machine was accomplished by Wm. Besler. The machine was a biplane originally built for a Curtiss engine, the Besler plant having been substituted for the latter. The installation included many parts taken from a Doble steam car which were unnecessarily heavy and in some cases too large for the purpose. No attempt was made to develop either extraordinary power or to make it extremely light.

The unit consists of a two-cylinder engine, which delivers approximately 150 hp at 1625 rpm. The weight is about 180 lb and no serious attempt was made to make the engine lighter. The boiler consists of a single tube approximately 500 ft long, and is built according to a patented design, the chief improvement over previous boilers being that the temperature remains constant regardless of the pressure, and the control is entirely automatic. The efficiency is very high.

The engine is fitted with a steam feedwater pump, the exhaust steam from this pump being used to preheat the feedwater entering the boiler. The power plant condenses about 99 per cent of the water used, and ten gallons are sufficient for an ordinary flight under reasonably cool weather conditions. To start the boiler, it is merely necessary to press a switch which starts an electric blower motor, causing air and fuel to be forced through the burner and into the boiler, where ignition is effected by a spark. From then on the automatic controls operate all the necessary functions, and the pilot has only to move the throttle and reverse lever, there being one position for forward and one for reverse. Apparently only a short flight was made. (*Discovery*, vol. 14, no. 163, July, 1933, pp. 220–221, 3 figs., *d*)

A Simplified Presentation of the Subject of the Spinning of Airplanes

IN THIS report, a broad view of the subject is taken, the argument being kept as short as possible, and some sacrifice in rigidity being made in the interest of clarity.

The report is not concerned with either the prevention of the involuntary spin, to which so much attention has been, and is still being, directed, or the problem of recovering from such an undeveloped spin; but exclusively to the problem of preventing such a spin from developing into a flat spin.

The aerodynamic characteristic which makes it possible for an airplane to spin is essentially the same as that which gives rise to the well-known phenomenon of "autorotation," namely, the automatic rolling motion which may occur owing to the fall of the lift beyond the stall. Autorotation, however, as commonly understood, refers to the behavior of a model mounted symmetrically so that it is free to rotate about the axis parallel to the wind direction through its center of gravity. The term may conveniently be extended to include the rotary motion which may be possible when the model is free to rotate at a radius and also in unsymmetrical attitudes; that is, rotary motion combined with sideslip.

Using autorotation in this wider sense, the author does not know of any arrangement of fixed wings which will not, with an appropriate amount of sideslip, autorotate rapidly at any incidence between, say, 30 and 80 deg.

Existing experimental information therefore indicates that the prevention of the rapid flat spin is to be sought not in the use of wings which cannot autorotate at high rates, but in measures which will insure that the wings cannot remain in those attitudes in which rapid autorotation is possible. Such measures are the provision of sufficient effective fin and rudder area, or its equivalent in depth of body near the tail; and it is the main conclusion of the report that the flat spin can generally be eliminated in this way without going to an impracticably large fin and rudder. There are, however, a variety of other characteristics which may be either favorable or unfavorable to the flat spin, and when, for any reason, it is not convenient to provide sufficient fin effect to override these influences, they may turn the scale from safety to danger.

The most important of these secondary factors is the relative distribution of weight along wings and body, which may give rise to a yawing inertia couple of some magnitude. The way in which this couple is caused by the centrifugal forces acting on the various parts of the airplane is simply explained. The sense in which the couple acts in a spin, however, depends not only on the weight distribution but also on the autorotational properties of the wings; the explanation in detail of its interaction with these properties is somewhat complex and is given in an appendix. The important point to observe,

however, is that the yawing inertia couple may be either helpful or harmful according to the type of design; that is, according to the wing arrangement and the way in which the masses are distributed. For example, in a monoplane or highly staggered biplane (which are broadly similar in aerodynamic characteristics), if the big weights are in the body, the yawing inertia couple will usually be harmful, while if the weights are in the wings it will be helpful. For an unstaggered biplane, on the other hand, to have the big weights in the body is preferable to having them on the wings so far as spinning is concerned. Again, if the stagger is moderate, the weight distribution will probably matter little.

The report aims at giving the designer some idea as to whether any particular aerodynamic-inertia combination is favorable or unfavorable, and to what extent. An indication is given as to the effective fin area required when the mass distribution and/or wing arrangement are such that the yawing inertia couple is of little account, and also as to the extent to which this should be increased in the worst case which is likely to arise.

It would appear that even when catering for the worst case, the effective fin area called for is not so large as to interfere with the general design of the airplane, particularly if a fair proportion of the total fin area can be provided by the body. Should there be no objection to a body of fair depth at the rear, the amount of effective fin required apart from the body is then quite moderate; while should, for some reason or other, a specially thin or circular body be desired, it is still possible in the worst case to attain safety without unusually large surfaces if a practicable design can be devised in which the fin and rudder are unshielded by the tailplane under spinning conditions.

If both the mass distribution and the wing arrangement are regarded as being outside the disposal of the designer, it remains broadly true that only by providing adequate effective vertical fin area can safety be attained. But if either the mass distribution or the wing arrangement, or both, are regarded as at his disposal, he may be able to reduce materially the fin area required.

Other characteristics, such as slots, fin area forward of the position of the center of gravity, dihedral and sweep back of the wings, etc., also affect the problem to a more or less minor extent, and their influence so far as it is known at present is discussed in the report and appendixes. The effect of slots on spinning is a question now receiving considerable attention. It would appear from the work done so far that so long as the spin does not tend to be flat, slots are generally, but not invariably, favorable in their effect; but should the spin become flat (incidence 60 deg or more), their effect may be adverse and of quite serious magnitude.

Summing up the various conclusions arrived at there is one outstanding conclusion which is as follows:

(1) By far the most effective means of insuring safety in spinning is to have a body which is both long and deep and in which the fin and rudder surfaces are unshielded by the tail-plane.

All the other conclusions are of relatively minor importance except, perhaps, in extreme cases, those relating to the yawing inertia effects. Consideration of the way in which the centrifugal yawing couple enters into spinning leads to the conclusions that:

(2) Types of airplane in which the centrifugal yawing couple is harmful and of appreciable magnitude are:

A Monoplanes
Very highly staggered biplanes, with their big weights in the body ($A - B$ negative and big)

B Unstaggered biplanes with weights on wings ($A - B$ positive and big).

Similarly, types in which the centrifugal yawing couple is helpful are:

C Monoplanes
Highly staggered biplanes, with weights in wings ($A - B$ positive)

D Unstaggered biplanes with large negative $A - B$. (Weights in body.)

Conclusions regarding various minor effects are as follows, always remembering that what is classed as a minor effect may assume great importance when too little margin of safety has been allowed:

(3) The effect of slots is likely to be beneficial in spins of no very great incidence, but in flat spins the effect may be adverse and of quite serious magnitude. It is therefore of special importance in cases where slots are fitted that the possibility of the flat spin should be avoided.

(4) Seaplane floats are less likely to have an adverse effect on spinning in the unfavorable combinations, *A* and *B*, than in the good ones, *C* and *D*. In *A* the effect may even be good. Floats will, however, tend to raise the limits of incidence within which spinning is possible.

(5) The high-wing monoplane is less liable to the flat spin than the low-wing monoplane. A tentative conclusion is that raising the wing by a chord length reduces the maximum incidence of the spin by something of the order of 10 deg.

(6) Additions to the vertical fin area forward of the center of gravity, such as may be brought about by a change of engine, the addition of a Townend ring or wheel spats are likely to have an adverse effect in monoplanes and highly staggered biplanes and a good effect in unstaggered biplanes.

(7) A dihedral angle is almost certainly an advantage in types *A* and *B*, i.e., the unfavorable combinations, and disadvantageous in types *C* and *D*, the favorable combinations.

(8) Sweepback of moderate amount is probably bad in the unfavorable combinations and good in the favorable combinations.

(9) In the markedly favorable combinations:

(*a*) Recovery is helped by moving the stick forward
(*b*) A forward position of center of gravity is favorable for recovery
(*c*) Decrease in height favors recovery.

In the markedly unfavorable combinations, all the above may be reversed. (H. B. Irving, from a press release of the British Air Ministry, *Reports and Memoranda*, no. 1535, Mar. 27, 1933, *t*)

Stipa Tubular Airplane

THUS far, only experimental and demonstration machines have been built by the Caproni plant to the design of Engineer Stipa. Fig. 1 shows the principle of this machine. It is stated that while the full efficiency of the device cannot be shown on an apparatus of small dimensions with limited motor equipment, it does indicate what can be done with larger units. From a theoretical point of view, there should be an improvement in propeller efficiency of the order of 12 to 15 per cent. Because of the tubular construction shown, the turbulence created by the air stream, and actually observable in other types of airplanes, is said to be avoided here. It is claimed that the use of the tunnel passage in the fuselage has certain other advantages, such as the reduction of parasite resistance and higher efficiency of the control surfaces due to the fact that they do not have to work in a region of highly

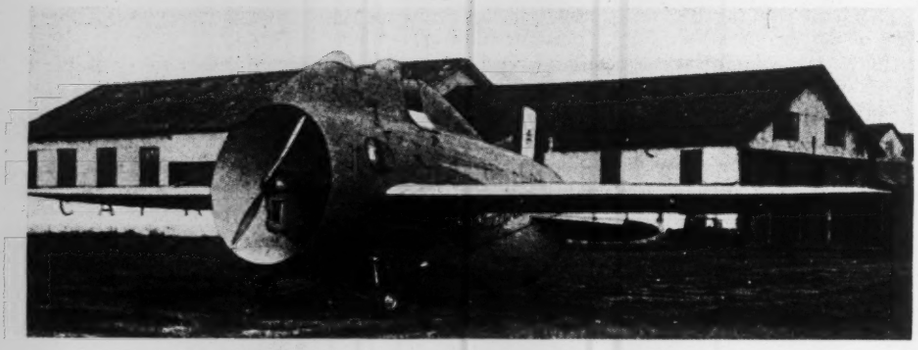


FIG. 1 STIPA CAPRONI TUBULAR AIRPLANE

disturbed air. An increase in the stability of the plane is also claimed.

As regards the decrease of frontal resistance, certain tests have been made in the aerodynamic tunnel in Rome. The section of the tube within which the propelling machinery is located has the shape of a Venturi tube. The cross-section of the part of the fuselage that forms the tube is approximately that of a wing profile. Each section of the wall of the tube therefore acts aerodynamically like the wing profile and generates an elemental aerodynamic reaction toward the axis of the tunnel. The total reaction resolves itself, therefore, into an annular compression of the walls of the tube and axial components. In accordance with the shape of that section of the wall, this axial component may act directly backward (resistance); have no action (the elementary aerodynamic reactions are then normal to the axis of the tube); or may be directed forward (propelling action). This last condition which is most difficult to verify is nevertheless characteristic and quite interesting. It may not be in evidence in the case of a multi-motor unit with the number of tubes more than one, and, in general, the cause of the diminished frontal resistance is primarily the shape of the structure or the elimination of the disturbance which the blades of the propeller create.

It is claimed that a multi-motor machine with "tubed" propellers may present the general appearance of a "flying wing," assuming however, that all the apparatus necessary for propulsion, for carrying the useful load, and for starting and landing can be hidden within a properly developed aerodynamic shape.

As regards the efficiency of the controlling surfaces, it is claimed that by having to operate in a well-regulated and continuous current of air, they perform far more efficiently than is the case today. It is also claimed that actual performance of the units built thus far indicates a far superior stability.

The characteristic dimensions are given in the original article. The unit shown is powered with an inverted Gypsy-III air-cooled motor. (Armando Silvestri in *Il Politecnico*, vol. 81, no. 2, February, 1933, pp. 106–109, *dA*)

ENGINEERING MATERIALS

Synthetic-Resin Products

THIS article is based on the Plastics Exhibition at South Kensington, London. The article is illustrated, and shows such plastic products as gear wheels to drive heavy machinery. There are already various classes of resins now made. The oldest used is bakelite. In addition to this, carbamide and thiocarbamide are used in admixture with formaldehyde. Carbamide is the better for making moldings of good dielectric strength. Thiocarbamide is prepared for the manufacture of ornamental wares and such domestic articles as cups and saucers. These products successfully withstand temperatures up to 130 C (266 F) and are entirely impervious to the action of all domestic liquids. The manufacture of resins from furfural has followed upon the discovery that the latter substance can be produced cheaply from waste vegetable matter, especially the offal from cereal crops.

In manufacturing a resin from furfural, a catalytic agent, such as aluminum chloride, is added, and the mixture subjected to a heat treatment, by which means the resinification process is accomplished in from one to two hours. Furfural is also used in conjunction with phenol in resin making, when the catalyst used may be hydrochloric acid or another mineral acid. British Patent No. 160,482 describes a process in which both pure cellulose and resin are produced from sawdust and phenol, using hydrochloric acid as a catalyst. Furfural is liberated from the sawdust, and combines with the phenol to form a resinous mass. Ammonia and furfural are frequently used in resin making, but as the resultant products are usually too soft for molding work, they are of more interest to the varnish industry. Furfural resins are generally more flexible than other synthetic resins, and thus may be used for purposes in which the latter are unsatisfactory, such as in the making of flexible gramophone records, printers' rollers, etc. Glyptal is a synthetic resin manufactured from glycerine, glycol, and phthalic anhydride. This resin has properties not found in some other synthetic resins. It may, for instance, be used for the bonding of mica products, for which purpose other resins are unsuitable on account of the smooth surface of the mica. It does not become brittle when subjected to very high temperatures, which is distinctly advantageous in many cases.

The details of manufacture of the resins and products therefrom are described in the original article and a brief discussion is given on the filling powders and the molding materials and processes. A semi-automatic press incorporating several improvements is described in the original article. Only a brief reference is made to the latest resin developments, such as vinyl resins. (*Engineering*, vol. 136, no. 3526, Aug. 11, 1933, pp. 131–133, 7 figs., *g*)

Oil-Resisting Rubber

THERE are five ways of making vulcanized rubber unsusceptible or little susceptible to oils. These methods may be divided into five groups:

(1) The vulcanizate contains as little rubber as possible, and much filling material.

(2) The vulcanizate contains materials which entirely envelop the rubber substance, as, for example, glue and gelatine; therefore, materials which are insoluble in organic solvent mediums.

(3) The vulcanizate contains soaps which have an action similar to the materials enumerated under group 2.

(4) The choice of the accelerators and the amount of sulphur, respectively, and the duration and the temperature of vulcanization.

(5) Surface protection.

In group 1, comparatively good results have been obtained with 25 to 30 per cent rubber and with larger amounts of inactive gas black. Good results are said to have been also obtained with reclaimed instead of raw rubber. In this connection, however, the purpose to which the material will be put is very important. In the case of oil-resisting hose, it is not always possible to manufacture a suitable product with a low rubber content in view of the mechanical properties. It is also important to know whether temporary or continuous resistance against oils is required. Generally, the method described in group 1 is not particularly to be recommended.

Materials of group 2 made with additions of such materials as glue and gelatine frequently have definite advantages. This method could be recommended for the manufacture of packing sheets, but is not suitable for hosing or flexible objects, as glue gives great hardness to the object. Addition of soap is, in many respects, similar to that of glue or gelatine.

Group 4 is the result of a colloidal chemical consideration. It is based on the reflection that the rubber, by long vulcanization at high temperature, is in a certain sense disaggregated, i.e., it is not so resistant to aging as rubber which is vulcanized for a short time at a lower temperature. The modern trend is broadly—independent of the problem of oil-resisting rubber—to preserve the rubber as much as possible by short vulcanization and low temperature. It is possible today to attain this end by the correct choice of the accelerator. It is even possible to go a step further, and with the knowledge that less sulphur gives better aging, reduce the amount of sulphur to a minimum that makes the old practical man shake his head. It is, therefore, established that the aging properties of the rubber are generally improved by the choice of the accelerator. In the case of oil-resisting rubber, however, it is necessary to choose an accelerator which fulfils these requirements to the fullest degree. Among the very considerable number of accelerators, it has been shown that these conditions are only fulfilled by the thiuram accelerators, namely, the mono- and di-sulphide. As these accelerators on vulcanization give off free sulphur, no addition of sulphur as such is necessary. This is the reason for the property of lack of swelling or "oil-resistance" of such products. In the same way, instead of the thiurams, other semi-ultra-accelerators have been used, together with very little sulphur and "barak." It has, however, been shown that the value of the "barak" was previously greatly overestimated. In any case, it is not possible to manufacture oil-resisting rubber by the latter methods.

As a result of measurements of swelling of thiuram-cured goods, it has been shown that many sheets and hoses could be used for over a year without decomposition. It should be noted here that the swelling data were only obtained in an empirical manner, namely, by measuring the weight and volume increases of a sheet dipped in vegetable and mineral oil at various temperatures. While the sheets, after one year, had experienced considerable volume increase, the mechanical soundness remained comparatively good, that is to say, no dissolution, or respectively, decomposition of the rubber could be established. The method is, therefore, perfectly feasible, and supports the adherents of the theory of short vulcanization at lower temperature. From a practical standpoint, however, the proposition is not finally satisfactory. One must take it that a sheet or a hose must be considered as useless after one year's use, for even if no decomposition has taken place, on the other hand, a considerable increase of volume has.

Surface protection is a compromise. As examples are cited, painting with cellulose varnish of benzene hose or spreading with linseed-oil varnishes. To sum up, the author believes that absolutely faultless oil-resisting rubber cannot be manufactured under the present-day state of rubber technology. (E. Karsten in *Kautschuk*, no. 5, May, 1933, pp. 73–74, abstracted through translation in *The India-Rubber Journal*, vol. 86, no. 5, July 29, 1933, pp. 9–10. g)

FUELS AND FIRING

A Burner for Creosote Oil

THIS matter attracted attention because of the desirability of providing a burner which would utilize a native tax-free oil. Creosote is produced in England by the gas and coking industries to the extent of 75,000,000 gal a year and is now quoted at about 57 s per ton as compared with 87.5 s per ton for imported mineral fuel oil.

Creosote, however, is more viscous than mineral oil and it has a certain degree of "tackiness." In the Brett burner

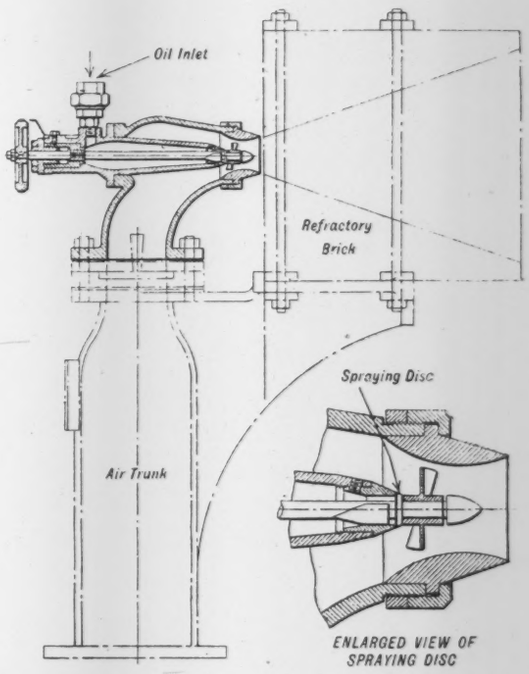


FIG. 2 CREOSOTE OIL BURNER IN SECTION

described here, this difficulty has been overcome by reducing to a minimum the restricted passage through which the creosote must pass in being atomized into a burnable mist.

The construction of the burner is very simple. The creosote is supplied under a gravity head of about 15 ft and at a temperature of about 105 F to the central tube, shown in Fig. 2. This tube is of cast iron, but its tip is finished with a hard-steel ferrule that has a bore of approximately $1/2$ in. The outside of the ferrule is turned down so that the orifice is brought to a thickness of 0.007 in. Inside the central tube there is a spindle, which at the back is provided with a fine-threaded screw and graduated handwheel, while at the front, just beyond the orifice, there is a disk of the same diameter as that of the outside of the nozzle. The screw enables the disk, guided centrally by feathers in the bore, to be adjusted very accurately to provide an annular outlet for the creosote, which is consequently sprayed out as an extremely thin disk. The only possibility of clogging, which may be caused on

account of the viscosity of the creosote, occurs at the narrow lip of 0.007 in., and it appears that if any clogging does take place it is quickly swept away again.

Just beyond the spraying disk the spindle carries a little two-bladed aluminum screw propeller, which is free to revolve. The air supplied to the burner, by a separately driven fan, first breaks up the disk-shaped jet of creosote and then carries it on to the propeller, which is rotated at a high speed by the draught and finally atomizes the spray. In front of the burner there is arranged a substantial block of refractory brick with a conical passage, that distributes the flame in the furnace.

In tests carried out with this burner, it has been found possible to heat 418 lb of steel bars in 60 min at a fuel consumption of $3^3/_4$ gal. This works out at 10.6 lb of steel heated per pound of fuel, or, in other words, the fuel cost per pound of steel heated is 0.029 d, or 34.6 lb of steel can be heated at the cost of one British penny. (*The Engineer*, vol. 156, no. 4048, Aug. 11, 1933, p. 144, 2 figs., *d*)

INTERNAL-COMBUSTION ENGINEERING (See also Railroad Engineering: Diesel-Electric Streamlined Rail Coach)

Motion of Valves in Internal-Combustion Engines

A CURIOUS motion of an exhaust valve of a Diesel engine in operation is observed by means of a concave mirror attached to the valve stem end and a point-light lamp whose beam is reflected by the mirror and focused on a screen. Some of the figures of the image on the screen are shown in Fig. 3.

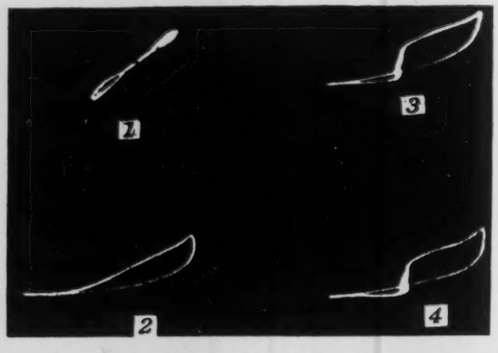


FIG. 3 LIGHT-BEAM RECORD OF A MOTION OF AN EXHAUST VALVE OF A DIESEL ENGINE

It would appear from this that at the instant when the rocker strikes the valve stem end, the valve has hardly made a downward movement before its rotation occurs. Stroboscopic observation would tend, however, to point out that there is hardly any time lag of the valve motion due to this cause. (Shun Huyita and associates, *Journal of the Society of Mechanical Engineers, Japan* (in Japanese), vol. 36, no. 194, June, 1933, pp. 402–405, 12 figs., *e*)

Scavenging in Two-Stroke-Cycle Motors

THIS is an extensive article of considerable interest but not suitable for detailed abstracting because of lack of space. The author considers the factors with which the numerical evaluation of the scavenging of two-stroke-cycle motors can be made, as well as the connection between scavenging pressure and consumption of scavenging material, and scavenging pressure and revolutions of the engine. He proposes approximate equations for the determination of these relations. He further shows that possible increase in output is limited by the performance of the scavenging process, which latter, therefore, deserves further investigation. Certain conclusions derived from this investigation may have a bearing on the application of two-stroke-cycle engines for motor vehicles.

The author emphasizes the fundamental lack of bases from which the process of scavenging might be investigated. (Dr. of Engrg. Herbert J. Venediger in *Automobiltechnische Zeitschrift*, vol. 36, no. 12, June 25, 1933, pp. 301–308, 20 figs., *etA*)

Process in a Gas Turbine With Special Reference to Pressure Firing

THIS is a continuation of the abstract of an article by Prof. G. Zerkowitz, the first part of which appeared in MECHANICAL ENGINEERING, September, 1933, pp. 577–580.

In calculating comparative values, one may assume also in considering the process of evacuating the chamber that the specific heats are constant, although actually at the high temperatures occurring during this process, the influence of variability of specific heats appears more evident than is the case in calculating the expansion part of the process. If we write accordingly

$$p_a v_a^k = \ldots = p_i v_i^k = \ldots = p_e v_e^k \quad \ldots\ldots [24]$$

we obtain, by integrating Equation [20], the following equation

$$L'_{\varphi 0} = RT_x G_a \frac{k}{k-1}\left[1 - \left(\frac{p_e}{p_a}\right)^{\frac{1}{k}} - \frac{\alpha\frac{k-1}{k}}{2-k}\left\{\left(\frac{p_1}{p_a}\right)^{\frac{k-1}{k}} - \left(\frac{p_1}{p_e}\right)^{\frac{k-1}{k}}\left(\frac{p_e}{p_a}\right)^{\frac{1}{k}}\right\}\right] \ldots [25]$$

The residual amount of gas at pressure p_e can be calculated from

$$G_e = G_a\left(\frac{p_e}{p_a}\right)^{\frac{1}{k}} \quad \ldots\ldots [26]$$

which makes it possible to convert Equation [21] to read

$$L''_{\varphi 0} = RT_x \frac{k}{k-1}\left(\frac{p_e}{p_a}\right)^{\frac{1}{k}}\left\{1 - \left(\frac{\alpha p_1}{p_e}\right)^{\frac{k-1}{k}}\right\} \ldots [27]$$

The theoretical work of the compressor amounts to

$$L_{k0} = \frac{k_0}{k_0 - 1} G_1 R T_1 \left[\left(\frac{p_3}{p_1}\right)^{\frac{k_0 - 1}{k_0}} - 1\right] \ldots\ldots [28]$$

providing we designate by k_0 the exponent of the adiabatic for the initial material. For gaseous fuels, $G_a = G_1$. For liquid fuels, G_a is equal to $G_1 + 1$.

In carrying through the calculation, the value of T_x is assumed and the desired "product of efficiency" ϵ is calculated from Equation [16a]. As long as the residue of the gases is permitted to flow through the turbine, we write $L_{\varphi 0} = L'_{\varphi 0} + L''_{\varphi 0}$, but if the residual gases are not passed through the turbine, then we write $L_{\varphi 0} = L'_{\varphi 0}$. By virtue of Equation [14a], the loss W_e is determined by the difference between the temperature T_x ahead of the turbine and the temperature T_3 obtaining after the compression. If $T_x = T_3$, the loss to the exhaust gas is 0. If T_x is permitted to become lower than T_3, the "exhaust-gas gain" is obtained, which means that the efficiency of the boiler exceeds 100 per cent on condition that side losses are left out of consideration. In such a case, the

average exit temperature of the gases leaving the turbine will be below the temperature of the ambient medium.

The author considers next at what "product of efficiency" $\epsilon = \epsilon_0$, the exhaust gas loss will be 0.

The results of this calculation are presented in Table 1 for an ideal gas of constant specific heat, i.e., in accordance with the assumptions laid as the basis of Equations [25] and [27].

TABLE 1 ϵ_0 VALUES FOR AN IDEAL GAS

		Without L''_{g0}	With L''_{g0}	Without L''_{g0}	With L''_{g0}
p_2, atm abs	1.5	2	2	3	3
$\alpha = 1$	0.480	0.664	0.557	0.813	0.641
$\alpha = 1.5$	0.665	0.840	0.76	0.968	0.785
$\alpha = 1.5$ with 10 per cent scavenging air	0.732	0.924	0.835	1.062	0.864

The calculation is made for $p_1 = 1$ atm abs and $p_2 = 1.5$, 2, and 3 atm abs, where p_a is equal to $.5\ p_2$. The ϵ_0 values have been determined for $\alpha = 1$ and $\alpha = 1.5$. The numerical values corresponding to $\alpha = 1$ have a merely theoretical interest, since an infinitely small drop in pressure of the gases occurring in the course of their flow over heated surfaces can take place only when the flow is at infinitely small velocities, which is in contradiction to the purpose of the process, namely, to increase the heat transfer and thereby reduce the size of the heating surfaces. In the last line of the table are given values for ϵ_0 with 10 per cent scavenging air. A certain amount of scavenging air is necessary to remove the gases from the combustion chamber and associated spaces, just as is done in two-stroke-cycle engines, and the compressor has to supply this scavenging air. This is estimated to be about 10 per cent.

Table 2 deals with the combustion of gas oil with a heat value of 10,000 kg-cal per kg (18,000 Btu per lb) with 20 per cent excess of air and the assumption that $p_2 = 2$ atm abs. Here, ζ_0 denotes that part of the heat of combustion which is given up to the water by conduction and radiation from the combustion chamber.

TABLE 2 ϵ_0 VALUES FOR OIL

ζ_0	0	0.3	0.5
p_a, atm abs	13.6	11	9.2
$T_a{}^0$, deg abs	2550	2000	1625
$\alpha = 1$	0.455	0.494	0.545
$\alpha = 1.5$	0.570	0.665	0.748
$\alpha = 1.5$ with 10 per cent scavenging air	0.614	0.710	0.795

Finally, Table 3 gives values of ϵ_0 for water gas at constant end pressure $p_2 = 2$ atm abs, it being stated that the water gas contains 53 parts by volume of hydrogen, 39 parts by volume of carbon monoxide, and 4 parts by volume of nitrogen.

TABLE 3 ϵ_0 VALUES FOR WATER GAS

ζ_0	0	0.3	0.5
$\alpha = 1$	0.531	0.581	0.635
$\alpha = 1.5$	0.672	0.773	0.886
$\alpha = 1.5$ with 10 per cent scavenging air	0.736	0.843	0.964

In all of these tables, ϵ_0 has been computed for $T_1 = 288$ C abs, $T_x = T_3 = 372$ C abs, which corresponds to $\eta_{ki} = 0.75$. It is, however, easy to calculate ϵ_0 for any other efficiency of compressor or any other temperature $T_3 = T_x$, since the work of the turbine is proportional to T_x. Thus, for example, if $\eta_{ki} = 0.82$, then $T_x = T_3 = 365$ C abs, and the values of ϵ_0 in the tables will have to be divided by $365/372 = 0.98$.

A comparison of Tables 1, 2, and 3 shows that oil behaves in the best and water gas in the worst manner, while the perfect gas with constant specific heat occupies the middle position, according to Table 1. This is easily comprehensible, as in the case of oil the mol value is greater after combustion than before, while the contrary prevails in the case of water gas. If we start with the ϵ_0 values for $\alpha = 1$; if we note that because of the radiation of heat ζ_0 cannot be equal to 0, and if finally we neglect the requirement of supplying scavenging air, it will be found that in the case of crude oil with $\alpha = 1.5$, ζ_0 is 0.3, $\eta_{ki} = 0.75$, $\eta_k = 0.735$, the efficiency product $\epsilon_0 = 0.665$, and hence η_g must be 0.905. With $\eta_k = 0.8$ and $\eta_{ki} = 0.82$, ϵ_0 will have the value of 0.65 and hence η_g must be 0.815, which cannot be obtained because of the constantly changing head of heat. If, further, the turbine has only one stage up to the charging pressure, we shall have to set the value of η_g approximately at 0.65, which will give an attainable efficiency product $\epsilon = 0.52$. The loss to exhaust gases taking place under these conditions is calculated from Equation [14a], by using

$$T_x = T_3 \epsilon_0 / \epsilon \quad \ldots\ldots\ldots\ldots\ldots\ldots [29]$$

For $\epsilon = 0.52$, we obtain $T_x - T_3 = 109$ C, from which the loss to exhaust gases appears to be about 5 per cent.

The value of $\epsilon_0 \cong 0.6$ for $\zeta_0 = 0.1$ is too high, even if the matter of scavenging air be neglected. Further calculations not reported here show that this value depends more on p_a than on T_a. In the examples it is considered that the water-vapor content in the working gases is precipitated during the expansion, and that therefore it does not do any work after reaching the temperature of condensation. Beyond that stage, however, the water condensed out of the gases (in exactly the same manner as happens with the turbine stages working in the region of wet steam) produces a braking action, lowering thereby η_g. If sulphur, even in very small amounts, is present in the fuel, special provisions must be made to prevent corrosion of machine parts, in particular, the blading.

CONSTANT-VOLUME PROCESS WITH PARTIAL CHARGING

According to the latest data, the process may be improved by operating the compressor not with a constant air pressure

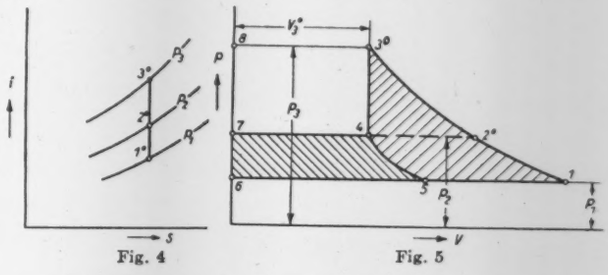


Fig. 4 Fig. 5

FIG. 4 *i-s* DIAGRAM FOR THE CHARGING COMPRESSION

FIG. 5 *p-v* DIAGRAM FOR THE CHARGING COMPRESSION

p_3 but as a means of driving the residual gases from the chamber with a lower pressure p_2. In this case, with the discharge valve closed, the chamber will be charged to the higher pressure p_3. This occurs, for example, because, during the period that the residue of the gases is being driven out, only one stage of the compressor works, while other stages are operated during the charging. Obviously, in such a case, the compressor cannot operate all the time at its maximum efficiency. The author derives an expression for the theoretical work of compression for such a case. Fig. 4 shows the processes that take place on the *i-s* diagram and Fig. 5 on the *p-v* diagram. It should be noted that $v = Gv$ and G is variable and the charging process represents a variation of the "quantity state."

It is only for the weight of the gas G_1 which is delivered to the chamber with the exclusion of the gas residue and is therefore in its entirety compressed from p_1 to p_2 that the following equation

$$AL'_{k0} = G_1 (i^0_2 - i_1) \quad [30]$$

holds good and shows in kilo-calories the work consumed, assuming there are no losses.

This is shown in Fig. 5 by the area 5–4–7–6 wherein 5–4 is an adiabatic. In the case of the charging process where the pressure gradually increases from p_2 to p_3, the theoretical expenditure of work amounts to

$$AL''_{k0} = \int_{p_2}^{p_3} (i - i_1) dG \quad [31]$$

If G_2 denotes the amount by weight of the gases present at pressure p_3 in the chamber at the end of the charging process, the following expression is obtained by integration of Equation [31]:

$$AL''_{k0} = G_2(i^0_3 - i_1) - G_1(i^0_2 - i_1) - AV^0_3(p_3 - p_2) \quad [32]$$

This work may be presented in the p-v diagram (but not in the T-s diagram) by a closed area, namely, 1–2^0–3^0–4–5. The whole theoretical work of compression is therefore

$$AL_{k0} = G_2(i^0_3 - i_1) - AV^0_3 (p_3 - p_2) \quad [33]$$

It is represented by the area 1–3^0–4–7–6. As compared with the compression of the entire mass of gas from p_1 to p_3 in a constant flow, the saving is represented by the area 3^0–4–7–8. The internal work required for compression is obtained from

$$L_{ki} = \frac{L_{k0}}{\eta_{k0}}$$

where, because of the variable heat head, a correspondingly lower value must be given to η_{ki}.

Because of losses, the real terminal state varies after the charging (point 3) from 3^0 down. T_3 is greater than $T_3{}^0$ and the volume content of the chamber V_0 is greater than V^0_3. To determine the loss to the exhaust gases, Equation [12], but not Equation [14] or [14a] may be used. The temperature T_3 occurring at the end of the charging does not in this case determine W_v. Instead, it is necessary to introduce an ideal temperature T_c, corresponding to an ideal heat content J_c which can be computed from

$$J_c = J_1 + AL_{ki} \quad [35]$$

The work of the turbine is obtained from Equation [25] by substituting $p_e = p_2$. The further available work L''_{a0}, as determined by Equation [27], need not be considered here, as the pressure p_2 has been deliberately selected as low as necessary for scavenging of the chamber and heating tubes so that there is no further fall of pressure in the turbine. This remainder is led through a separate preheater, which means that Equation [12a] has to be used. If T_x is low, $T_x = T_v$. The author introduces next the symbol $\epsilon_0{}^*$ for the efficiency product, this term implying that the fall of pressure is variable not only for the turbine but also for the compressor, and then he states that with the value of efficiency product corresponding to a zero loss to the exhaust gases, $T_x = T_v = T_c$.

Then, if $p_1 = 1$, $p_2 = 1.5$, $p_3 = 2$, $p_a = 10$ atm abs and $\alpha = 1.5$, $\epsilon_0{}^* = 0.54$ for an idealized gas and $\epsilon_0{}^* = 0.48$ for gas oil with 20 per cent excess air.

With $p_1 = 1$, $p_2 = 1.5$, $p_3 = 3$, $p_a = 15$ atm abs and $\alpha = 1.5$, it is found that $\epsilon_0 = 0.515$ for an idealized gas and $\epsilon_0 = 0.46$ for oil. It would appear, therefore, that with partial charging a lower product of efficiency is sufficient to make the losses to the exhaust gas zero. Thus, for example, the value $\epsilon_0 = 0.6$ can be attained with $\eta_a = 0.65$ and $\eta_k = 0.7$, which, in view of the varying loss of pressure, is still somewhat high, although in actuality the loss due to scavenging must be taken into consideration and hence a larger amount of air than G_1 must be handled.

FIRING EFFICIENCY AND FUEL EFFICIENCY

From the entropy diagram (Fig. 4, p. 579, MECHANICAL ENGINEERING, September, 1933), and from numerical calculations, it follows that even when the loss to exhaust gases is from 5 to 10 per cent, the first gas particles leaving the turbine may be cooled below the temperature of the ambient medium. Because of this, these gas particles are ultimately supplied with the heat from the ambient medium, whereas particles leaving the turbine later give up heat to the ambient medium. If the amount of heat given up predominates, there is a loss to the exhaust gas; if the reception of heat predominates, there is a gain to the exhaust gases, which means that heat of ambient medium is utilized for purposes of steam generation. This phenomenon is new and it cannot be explained by a comparison with the heat pump. With the latter, it is possible to obtain from a small amount of heat at a high temperature

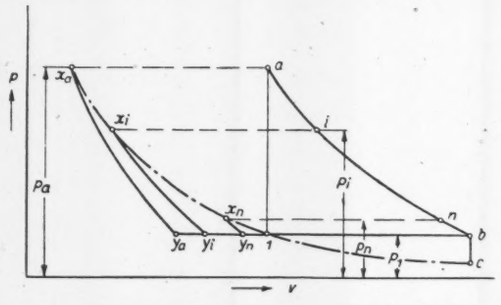


FIG. 6 p-v DIAGRAM FOR THE PROCESS WITHOUT PRECOMPRESSION

a larger amount of heat at a lower temperature, but it is impossible to get out of a heat pump a larger amount of work. In the case of an over-pressure boiler, on the other hand, where there is a gain from the exhaust gases, more steam may be obtained, and, under similar conditions, more work secured from the steam turbine than with another type of boiler. This additional action is due primarily to the use of the explosion process. The maximum irreversibility in an ordinary steam plant is due to the fact that the high-temperature heat from the working gases is transferred to the steam. This loss can be reduced by the use of explosion, because, on account of the higher gas pressure, a gain is possible either in the form of heat or in work. That we are not dealing here with the case of a heat pump is best shown by means of an ideal process where no compressor is provided. One might think of the process as having been changed in such a way that the explosion begins at atmospheric pressure (Fig. 6). The combustion chamber is equipped merely with an admission and a discharge valve. At the beginning of the explosion, there is present in the chamber a combustible gaseous mixture together with a certain amount of gases of combustion (point 1, Fig. 6).

After the explosion 1-a, the chamber may be emptied through the heating pipes and the change of state in the chamber may take place along the adiabatic a-b. In the ideal case, it may be assumed that the flow of gases through the heating pipes does

not involve any fall of pressure. The first particle of gas cools from a to x_a. Any ith particle cools from i to x_i and the nth particle, the pressure of which is p_n cools from n to x_n. The difference $p_n - p_1$ can be made as small as desired. The points x_a, x_i, and x_n lie on an isothermal, T_1. At the end of the chamber there remains an amount of gas

$$G_b = G_a \left(\frac{p_1}{p_a}\right)^{\frac{1}{k}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [36]$$

the temperature of which

$$T_b = T_a \left(\frac{p_1}{p_a}\right)^{\frac{k-1}{k}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [37]$$

is higher than T_1. In order that a new charge of gas may enter the chamber of which the valves are closed, the chamber contents must be cooled down, as, for example, by passing cold water through pipes installed in the chamber. In the limiting case, the chamber contents may be cooled down to T_1, whereupon the pressure falls from $p_b = p_1$ to p_c. If the inlet valve is opened, a fresh charge flows in, which is followed by a new explosion. In this way, the entire heat liberated by the explosion may be transferred to the water and from this water work can be generated in a gas turbine, in the course of which the first gas particle is expanded from x_a to y_a and the ith gas particle from x_i to y_i, etc. In this case, in addition to heat, useful work is obtained from the gases. In the explosion process with precompression, a gain from the exhaust gas is fundamentally possible. Whether it can be done in practise depends on local conditions for each case, particularly on the efficiency of the turbine and compressor. In accordance with calculations, it would appear that a certain loss to exhaust gases is more likely to take place. An essential condition for the operation of the process is that cold feedwater should be available and furthermore the steam turbine must not be provided with bleeder preheating. Whereas this leads to a simplification of the power plant, one must not forget that the improvement in fuel efficiency provided therein is precluded from the start. If, notwithstanding the variable head, a favorable value of η_g is obtained with a gas turbine, the temperature T_x of the turbine (contrariwise to what happens in the constant-pressure process) is so low that it is possible to make T_x higher in so far as construction alone is concerned. Therefore, less steam might be raised in the boiler or, the turbine might be equipped with bleeder preheating and by these methods more work could be obtained from the gas turbine than is needed by the compressor. There would, therefore, result a steam turbine with which useful work would be obtained both from that turbine and from the gas turbine.

Zero loss to the exhaust gases does not mean a firing efficiency of 100 per cent, as incidental losses must be considered. In any event, there is no intention here to claim a fuel efficiency of 100 per cent, as we are still very far from attaining the maximum work possible even with an irreversible combustion. Such an amount of work is theoretically obtainable only when the gases of combustion may be used directly as the working fluid. In such a case, however, there would be no useful purpose attained in letting the gases expand below the temperature of the ambient medium, and then supply them with heat from the ambient medium, as in doing so it would be necessary to go below the pressure of the ambient medium and then recompress the gases. The possibility of utilizing to a small extent the heat of the ambient medium is therefore only present if and when the furnace gases are used as a source of heat. Such additional work as is obtained indicates merely a small mitigation of the large irreversibility, which causes the transfer of heat from the gases to the working fluid. (Second and last instalment of an article by Prof. G. Zerkowitz, Munich, in *Die Warme*, vol. 56, no. 16, April 22, 1933, pp. 243–249, 7 figs., *tA*)

Internal-Combustion Turbines

THIS is an extensive article of general interest. The author considers first the various possible cycles of an internal-combustion engine, from which he proceeds to the consideration of the efficiency of a compressor-turbine group. He points out that the total efficiency of the group falls off much more rapidly than the individual efficiencies, and therein lies the fundamental weakness of the idea of a compressor-internal-combustion-turbine combination, a weakness which he considers inherent to the idea of such a combination and impossible to remove. The same weakness is essentially present in the case of an internal-combustion reciprocating engine making its efficiency comparatively low. The reciprocating engine, however, has an important advantage as compared with the turbine in that in the former the compression and expansion take place in the same cylinder, which eliminates a good share of the losses, such as those due to the clearance space, etc.

The author supports these observations by calculating the efficiency of an internal-combustion turbine and comparing it with the efficiency of a reciprocating engine. In so far as the turbine is concerned, he considers the constant-pressure cycle and the explosion cycle. He finds, among other things, that the turbine is far more sensitive to load variations than the reciprocating engine, this being due to the relatively greater influence on efficiency of the work of compression, the absolute value of which remains the same even when the power output decreases. He considers next the admissible maximum temperatures and heat drop. With constant pressure, the walls of the combustion chamber remain constantly in contact with the hot gases, which even with powerful external cooling imposes certain limitations due to the ability of the walls to stand the temperature. Such temperatures as 1500 to 2000 C are far too high to be used practically. In the explosion cycle, the walls of the chamber are submitted to effects essentially the same as those of a chamber of a reciprocating engine and feasible temperatures can be maintained. There may, however, be trouble with the valves.

The author considers next the matter of the maximum temperature which can be maintained without disastrously affecting the blades. He calls attention to the fact that when a metal is heated, the limit of proportional extension is lowered. Furthermore, when a metal is heated, and simultaneously even a comparatively low stress is applied continuously, expansion takes place up to a certain point and then ceases. It is evident, therefore, that in order to maintain the apparatus in good shape, it is necessary to keep the load below the limit where if applied continuously it will produce the slow expansion (creep). It is this limit, called limit of elastic expansions, that characterizes the resistance of metal to heat.

The author considers ways of cooling the blades but does not recommend any. He compares the constant-pressure-combustion cycle with the explosion cycle, and comes to the general conclusion that the former is more promising. The remainder of the article is based on the publication by Roy in Bulletin de l'Association Technique Maritime et Aeronautique, 1928. (P. Lorain, *La Revue Industrielle*, vol. 63, no. 2288 and 2289, July and August, 1933, pp. 321–329 and 379–387, 22 figs., *dcg*)

LUBRICATION

Re-Refining Used Automobile Lubrication Oil

ACCORDING to the author of the original article, the use of reclaimed or re-refined lubricating oils for automobile engines has increased rapidly within the past few years. This is ascribed largely to economic reasons as well as the realization by many car owners that these oils are perfectly satisfactory when properly re-refined.

Present refinery practise is to treat the lubricating oils for an arbitrary standard of color, viscosity, sulphur, carbon residue, and demulsibility. The merits of these standards are not definitely established. A re-refined oil from an average source, treated to meet the accepted standard tests, should have properties between those of Pennsylvania and Mid-Continent lubricating oils. This oil is a mixture of these two grades of oils and has been through three distinct refinings, the original refinery treat, the engine service treat, and the re-refining treat.

In the tests reported here, a study has been made of a composite sample of automobile crankcase drainings obtained from several filling stations. This oil contains some differential gear grease, which makes the treating more difficult, but gives conditions that will be met in commercial treating plants.

The fractional distillation curve is given in the original article. All of the fractions have a characteristic odor, which is removed in treating. A summary of the results is given in the original article. The author believes that the gravities have no particular significance except for comparison. The colors of the finished oils generally were not satisfactory. The overhead lubricating oils have light colors comparable to the well-fractionated virgin oil now marketed. The viscosity indicates that reclaimed oils are in this respect between the Pennsylvania and Mid-Continent oils. This is to be expected, as the drainings represent a mixture of both types of oils.

The author comes to the following conclusions:

Satisfactory automobile-engine lubricating oils can be made from crankcase drainings. It is essential that the proper method of refining be employed in order to obtain satisfactory finished oil.

These re-refined oils have been through three distinct refining processes which should remove the relatively unstable components of the virgin oil. This is indicated by determinations for iodine numbers on oils before and after use. On this assumption, the re refined lubricating oils should be equal to or superior to the virgin oils from the standpoint of chemical stability.

More fundamental knowledge of the mechanism of lubrication and of the lubrication properties of petroleum oils is essential before the different types of lubricating oils can be properly classified. (Ellis C. Pattee, University of Michigan, Ann Arbor, Mich., in *National Petroleum News*, vol. 25, no. 28, July 12, 1933, pp. 29–31, *e*)

Improvements in Pennsylvania Lubricating Oils

RECENTLY developed processes are said to increase the viscosity index and improve other properties of Pennsylvania oils. (The importance of a flat temperature-viscosity curve has led to the conception of a "viscosity index" in which this property is given a more quantitative expression.) It is said that the higher the viscosity index of an oil, the fewer are the grades required to provide ample viscosity at high engine speeds and temperature and ready starting in cold or winter conditions.

By the use of solvent extraction, it has been possible to make from Pennsylvania oils, oils of certain improved characteristics. These improvements are increased viscosity index, higher flash and fire points, reduction in carbon residue, and improvement in color.

It should be noted that solvent extraction and fractional distillation in some cases effect similar improvements. However, with Pennsylvania oils, solvents are today the only effective way of increasing materially the viscosity index. The data in Table 9 (not reproduced here) show the results obtained by solvent extraction of Pennsylvania neutral oil and bright stocks.

In some respects, extraction and distillation are interrelated processes, each capable of producing a certain effect more advantageously than the other. (M. R. Fenske, Pennsylvania State College, paper before Pennsylvania Grade Crude Oil Association, June 29–30, 1933, abstracted through *National Petroleum News*, vol. 25, no. 27, July 5, 1933, pp. 33–36, including 9 tables, *e*)

MACHINE PARTS

Contact Between the Screw Threads of Nuts and Bolts

THE nature and magnitude of this distortion in the case of mating screws differing in pitch and thread angle by amounts commonly encountered in present practise have a bearing on the development of standardization which is under investigation at the National Physical Laboratory at Teddington. Fig. 7, which shows the section of a $\frac{1}{2}$-in. B.S.F.

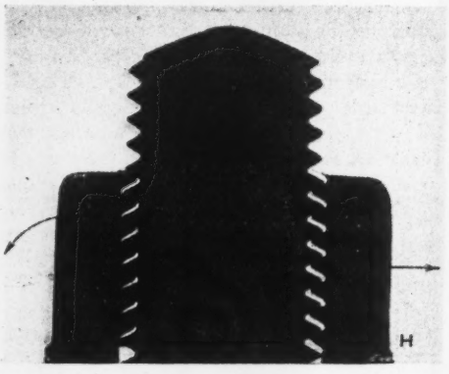


FIG. 7 PHOTOGRAPH SHOWING THE NATURE OF THE CONTACT BETWEEN THE SCREW THREADS OF NUTS AND BOLTS

bolt and nut, is typical of the condition in which the base of the nut is slightly (0.01 in. in this case) out of square with the axis of its screw thread, the high point being on the side marked *H*. The concentration of pressure on the base at this point has caused the nut both to tilt and to become displaced laterally in the direction of the arrows. (Part of a serial article describing the work at the National Physical Laboratory, Teddington. The present abstract is taken from *Engineering*, vol. 136, no. 3527, Aug. 18, 1933, p. 175, 1 fig., *p*)

MACHINE TOOLS

The NRA and the Machinery Industry

FOREMOST among the problems raised by the National Industrial Recovery Act, in so far as the machinery industry is concerned, is the question of whether or not the general result of NRA policy will be to discourage the use of machinery.

Certain observations on the position of the machinery industry in the new coordinated economy have direct bearing upon the trade's future.

Administrator Johnson has declared that "the necessary installation of new equipment should go forward," although adding that "for a short period it would be wise not to emphasize the installation of machinery that would tend to further reduce the field of employment." The emphasis has been upon new equipment installations for replacement rather than for expansion.

Additionally, it is understood that the Government has not asked for code clauses which restrict the purchase and installation of new equipment. Limitation of working shifts, such as in the textile code to two shifts of 40 hr per week, should tend to encourage the installation of more efficient equipment.

The Public Works Administration likewise has indicated that preference for hand labor will not be carried beyond a point where it ceases to be economical. Not only would such a policy, it is held, impose undue financial burdens upon communities borrowing from the Government to carry out public-works projects, but, by exhausting the fund at an early date, would prevent other communities from sharing in the program.

Code agreements not to sell below cost will indirectly handicap the high-cost producer using obsolescent equipment. This very emphasis upon costs, it is believed, might well initiate a program of plant modernization, without adding to the total industry capacity.

Indiscriminate expansion of plant capacity in any industry without regard to markets probably will be prevented by the NRA. While such a policy apparently precludes as high a rate of activity as obtained in the machinery industry during 1929, it does not rule out the possibility of a substantial expansion in machinery outturn from present low levels. (*Standard Trade and Securities*, vol. 69, no. 24, Aug. 25, 1933, Section 1, p. M-8, *g*)

MOTOR-CAR ENGINEERING

Automatic Transmissions

AN AUTOMATIC transmission should be so designed as automatically to establish the best operating conditions for the car, but what are the best operating conditions? Some would look at the subject from the standpoint of maximum acceleration and maximum speed, while others would regard it from the standpoint of maximum economy. The author comes to the conclusion that the engine power should be kept constant by the automatic transmission, that is, the power that passes through the transmission. The requirements for an automatic transmission at first appear contradictory.

During acceleration, in order that the engine may be maintained at or near its peak speed, as the load on the engine decreases the gear ratio must be decreased.

In steady driving, as the load on the engine decreases due to grades, etc., and it is pulled down in speed, the gear ratio must be increased in order to bring the engine back to its peaking speed.

There are four factors that could be used theoretically at least to control the transmission ratio. These are engine speed, engine torque, axle speed, which means car speed, and axle torque.

The author points out certain advantages for engine-speed control and points out how this can be achieved.

The question as to whether engine torque or torque reaction can be made to control an automatic transmission would have been answered in the negative some years ago when it was considered necessary to bolt engine blocks down rigidly to the car frame. Today, power plants may be mounted on the chassis in such a way that they will rock through a considerable angle under the influence of changes in engine torque. If the engine moves angularly as the torque load on it varies, it would seem to be possible to cause it to change gears, engage friction clutches, or change the setting of a continuously variable transmission.

There is another difficulty, however, which on first thought seems to make it impossible to utilize the engine torque for this purpose. This lies in the fact that when the engine is at rest it must be disengaged from the driving mechanism in order that it may be cranked by the electric starter without too heavy a current draw, or even by hand in an emergency. But if the engine is disconnected from the drive there is no torque load on it. However, if the throttle were opened suddenly, a momentary torque impulse would result from the inertia of the flywheel, crankshaft, etc., and the engine would be deflected from its position of rest. This yield of the block under inertia-torque might be used to engage the friction clutch of the low gear. But since this torque impulse persists for a short time only, the operation of engaging the gear in this manner naturally would be somewhat delicate.

There are other difficulties which lead the author to the conclusion that automatic control of transmissions by engine torque is not very promising. If effected in the manner described by the author, not only would it cut down the average acceleration of the car by making it impossible to run in low gear with the throttle well opened, but it would cut down the economy by making it impossible to run in high gear when the traction resistance was low. (*Automotive Industries*, vol. 69, nos. 1 and 2, July 1 and July 8, 1933, pp. 4–6 and 43–44, illustrated, *gd*)

Pneumatic Tires for Farm Tractors

ON WEDNESDAY, August 2, some interesting trials were made at Sutton Codfield with a farm tractor equipped with specially designed low-pressure Dunlop pneumatic tires. It was demonstrated that a tractor so fitted could be used equally well on the land or on the roads, and, by employing a trailer, could quickly transport implements, fuel, and men from one place to another. The wheels used were of cast steel. The total weight on the rear wheels was 720 lb with 470 lb on the front wheels, including tires. A different pattern of tire is employed for each set of wheels, that for the rear wheels being specially designed to throw off soil and mud, and to remain unclogged, while the tires for the front wheels have a deeply ribbed tread, insuring a steady steering course. Tests were made with a two-way single-furrow plow, with which a depth of 16 in. was attained, there being no tendency for the tractor to slew toward the furrow. Other tests were made with a double-furrow plow and a nine-strake cultivator, and served to show the non-slipping characteristic of the new tires. It is claimed that the fitting of pneumatic tires to farm tractors will show economies similar to those which have been obtained with rubber-tired vehicles for road and rail transport. (*The Engineer*, vol. 156, no. 4048, Aug. 11, 1933, p. 127, *e*)

PETROLEUM ENGINEERING (See Lubrication: Re-Refining Used Automobile Lubrication Oil)

POWER-PLANT ENGINEERING (See Aeronautics: Besler System of Steam Power for Aircraft)

PUMPS

Rotary Displacement Pumps

THREE-THROW pumps have been long employed for high-pressure work. When, however, large deliveries are required, the size of pump and the necessity for large stiff countershafts, alignment, and the lubrication of numerous bearings have made maintenance at times difficult. A more recent development of the rotary pump is the 7/8 type, which consists of a seven-lobed inner rotor working inside an eight-lobed outer rotor, this giving the particular advantage of avoiding impulse and enabling the pump to give absolutely steady pressure discharge. The displacement is effected by the lobe of the inner rotor engaging with the lobe recess of the outer rotor and simultaneously moving forward on the latter. The combination of such a system of inner and outer rotors has a very smooth action, which, together with the exact nature of the curve and its correct production in the workshops, is said to be responsible for the mechanical efficiencies attained. Fig. 2 of the original article shows the efficiency curves of a lubricating-oil pump under various discharge pressures and with oils of two different viscosities. The efficiency rises with increasing pressure and with the working range. For the pump under consideration, the efficiency is shown to be between 89 and 92 per cent. The use of higher-viscosity oil decreases the efficiency, but the curves are of the same general shape. (C. S. Darling, *Industrial Pumping Practice*, Supplement to *Mechanical World*, June 9, 1933, pp. 11–13, 7 figs., *d*)

RAILROAD ENGINEERING

FWD High-Speed Rail Bus

THIS bus was designed by the Four Wheel Drive Auto Co., of Clintonville, Wis. It is 30 ft long and 7 ft 7 in. wide with accommodations for 35 passengers. Driven by two 86-hp motors, it is said to be capable of attaining speeds in excess of 70 mph. Each axle is driven by a separate motor through a separate three-speed transmission. Controls to the individual drives are synchronized and manipulated through a single set of levers in the operator's compartment. Either drive unit can be shifted into neutral, enabling the bus to operate at a modified rate of speed in the event that one power system should be temporarily displaced. The power transmission system is equipped with high-speed reverse mechanism which operates through all the transmission ranges and gives the car equal speeds in either direction. It is claimed that the fact that all four wheels have tractive ability, gives the car unusual acceleration and at the same time helps maintain rail adhesion by distributing the driving force to four instead of two wheels. To demonstrate the advantages of four-wheel drive, a test was run on a Southern railroad with one axle disconnected and another test over the same road bed with all four wheels driving. The high speeds attained safely with the four wheels driving were found to be objectionable when only two wheels propelled the rail bus, as it swayed and rocked dangerously. It has also been found that maintenance of the four-wheel-drive equipment is considerably lower, due to the fact that the driving strains are divided. The wheels on the FWD rail bus are of the rubber-insert type, wherein a thick layer of resilient rubber is vulcanized securely on the inside of a regulation MCB steel tire. The steel tire with the rubber cushion is securely pressed on to the steel wheels, making a completed unit which is capable of long service under heavy loads. The cushioning effect of the rubber dampens the rail vibration and gives a new conception of comfort in railroad travel. Fig. 8 shows a series 80 bus chassis. (Abstract of a publicity release issued by the Four Wheel Drive Auto Co., Clintonville, Wis., mimeographed, *d*)

Diesel-Electric Streamlined Rail Coach

THIS coach was built by Sir W. G. Armstrong, Whitworth & Co. (Engineers), London, to provide a frequent high-speed local service on rails, and must be distinguished from the "Tyneside Venturer" coaches of the same firm. When fitted with a 95-bhp engine, it weighs only $17\frac{1}{2}$ tons in working order, roughly from $\frac{1}{4}$ to $\frac{1}{3}$ of a ton per passenger. (A 140–150-hp engine may be installed.)

The ends and sides of the coach are streamlined and a deep skirting round the sides is provided to diminish the eddies under the frame. It is claimed that by reducing the head resistance in this way, a saving of power of not less than 30 per cent can be effected at normal cruising speed. The power unit consists of an Armstrong-Saurer commercial-vehicle six-cylinder heavy-oil engine arranged with three-point support in rubber bushes. The engine is directly coupled to the generator which, in turn, is connected to the traction motor rigidly mounted on the underframe, the power being transmitted to the road wheels through a cardan shaft and Craven-Guest worm gearing. The details of control are described in the original article, which applies also to construction.

The maximum speed with the 90-hp engine is said to be 60 mph, and 75 mph with a 150-hp engine running at 1500 rpm. (*Engineering*, vol. 136, no. 3526, Aug. 11, 1933, pp. 152, 2 figs., *d*)

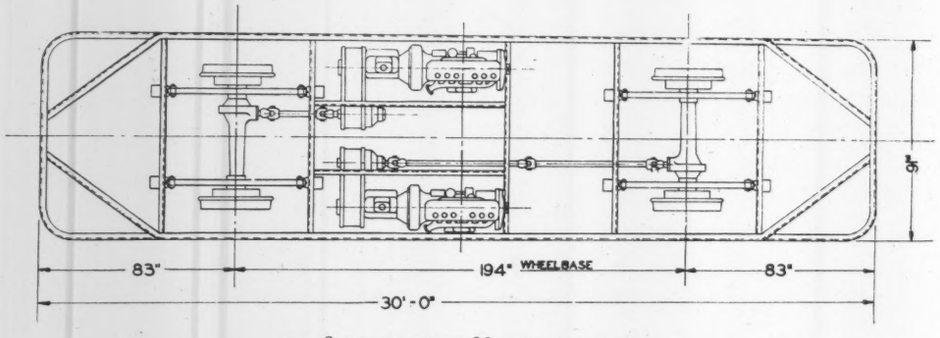


FIG. 8 FWD SERIES 80 RAIL-BUS CHASSIS

SPECIAL MACHINERY

Rotary Shears

THIS describes a type marketed by Henry Pels & Co., Ltd., London. The plate to be sheared is firmly gripped on a table. The friction caused by the revolving circular cutters and the resting plate makes the shears move forward and cut the material. The cutting length of the shears is unlimited as compared with guillotines, where, owing to the limited

length of shear blades, long plates may only be sheared through a tedious and cumbersome pushing forward of the plates. The cutting length is dependent upon the table holding the plate and its accompanying rail, which, at a comparatively small cost, can be made suitable for individual requirements. The resultant advantage of a comparatively inexpensive plant makes the latter then capable of dealing with any length of cut.

At the end of the cut, the shears automatically stop. The following cut is done in the opposite direction by reversing the motor; thus no idle reverse motion takes place. For strip shearing, the depth of throat can be made to vary from 16 in. up to 30 in., so that strips up to that width can easily be sheared. A wide adjustability of the circular cutters causes strips beyond a certain width to remain perfectly flat; they do not bend nor are they twisted.

Arrangements are provided for shearing beveled edges. It is also claimed that owing to the rigid guidance of the moving shears, the cuts are straight and not curved. By adding a speed regulator for direct-current motors or a pole-changing switch for alternating-current motors, thinner material can be sheared at a higher speed. The details of the various controls are described in the original article, where also are illustrated methods for cutting bevel edges for welds or plates of stock size and cutting bevel edges on plates previously sheared to size. (*Sheet Metal Industries*, vol. 7, no. 76, August, 1933, pp. 241–242, 5 figs., *d*)

STEAM ENGINEERING

The Working Cycle of the Velox Boiler

A COMBUSTION efficiency of more than 100 per cent has been claimed for the cycle employed in the Velox boiler. The author investigates the thermodynamics of the boiler under certain assumptions, namely, that the working fluid is a perfect gas, that all the compressions and expansions take place adiabatically, and no pressure and other losses occur, so that the pressure is the same in the combustion chamber as in the pipes leading to the turbines. The actual process may be regarded as taking place between two limiting cycles. In the first place, the gas is compressed adiabatically. Combustion at constant volume then occurs and this is followed by cooling and expansion in the reverse direction. The second cycle is the same up to the conclusion of combustion at constant volume, the gas being compressed in the compressor so that the heat supplied corresponds to the calorific value of the mixture. The pressure in the chamber now falls owing to the escape of the charge and an increase in the specific volume occurs adiabatically.

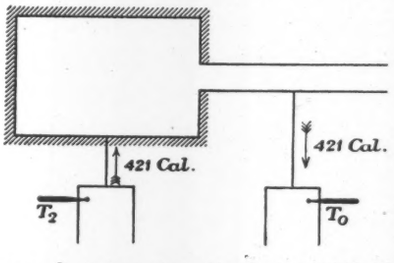


FIG. 9 HEAT DIAGRAM WHERE COMBUSTION CHAMBER IS CONNECTED TO AN INFINITELY LARGE VESSEL AT TEMPERATURE T_0

Next, the volume of gas which escapes is cooled in the evaporator or cooling tubes at constant pressure to the initial temperature and a certain amount of heat which can be calculated is liberated. The heat process is set forth in detail in the original article, and a numerical example is given to make the relationship clearer. From this it would appear that in addition work is done and a cooling process set up, since the heat drawn from the surroundings can be used for cooling. In this case it may be said that an efficiency of more than 100 per cent is obtained. The cycle is only apparently contradictory to the second law of thermodynamics, which has been formulated by Planck to read, "It is impossible to construct a cyclic engine which does nothing but raise a load and cool a heat reservoir."

The contradiction is only apparent, because the heat supplied to the machine is not of equal thermodynamic value to the heat transmitted, a conclusion which has already been reached in *Engineering* by other reasoning. If, for instance, the heat was supplied by connecting the combustion chamber to an infinitely large vessel at temperature T_2, Fig. 9, and the heat on the other side was extracted by connecting the cooling air with another infinitely large container at temperature T_0, the toal heat, 421 cal, would pass from the high to the low level, the work performed being only 27 cal, and work done in cooling being supplied from the same level. The cycle would, therefore, have a low efficiency.

Naturally, another method would be chosen, instead of this unsuitable process, for extremely high-temperature steam. With any other process, however, the efficiency of the whole installation—boiler and machine in which the steam is used—cannot be greater than the maximum given by $(T_2 - T_0)/T_2$. (O. Klüsener, *Engineering*, vol. 136, no. 3527, Aug. 18, 1933, p. 176, 4 figs., *t*)

Loffler Boilers at Trebovice

THE TREBOVICE, Czechoslovakia, station is one of the most recently completed in Europe, the building having been commenced in the summer of 1931, and put into service in February, 1933. It works exclusively with steam at 1849 lb per sq in. (130 atm) pressure and 500 C (932 F) temperature. Full use is made of the advantages of extracted steam for preheating and of intermediate superheating. The coal, simultaneously with grinding, is dried by means of flue gases, and the mixture of coal dust and flue gas is blown by means of fans into cyclones which are arranged over the coal-dust bunkers of the boiler and effect the separation of the coal dust from the flue gases. The coal dust is led to the burners where it becomes thoroughly mixed with highly preheated air for combustion. After passing through a special Witkowitz burner, the coal dust is ignited by means of radiant heat from the ignition arches and burns for a distance of 4 to 6 m (13.1 to 19.6 ft). The gases formed from the combustion stream over the heating surfaces and collect in the main flue whence they are discharged to the atmosphere through a chimney 328 ft high.

Three Löffler boilers of approximately 67 to 75 tons of steam per hr have been installed. They deliver the steam into a main pipe line, from which it passes through separators to two Skoda turbines, each of which is designed for an output of 21,000 kw. Each turbine is arranged with three cylinders, and steam is extracted at three points for the purpose of heating the feedwater.

The outlet steam from the first cylinder is fed to an intermediate superheater where it is heated to a temperature of 340 C (644 F) by means of fresh steam. It is led at this temperature into the second turbine cylinder where it expands to the vacuum pressure.

The following figures for heat consumption in Btu per kilowatthour have been calculated: For 100 per cent loading, 13,167; for 70 per cent loading, 12,988; and for 40 per cent loading, 14,553 Btu per kwhr.

It is interesting to compare the heat consumption per net

kilowatt attained in the Trebovice plant with the heat consumption of a medium-pressure plant. For this comparison the Klingenberg power station has been selected, the economy of which was thoroughly investigated and described by Tröger in the *Zeitschrift des Vereines deutscher Ingenieure*, vol. 53 (1927). In the above article, Tröger gives a table in which the relation of the heat consumption per net kilowatt of loading is given. These values are given as ordinates above those of the central-station loadings, and are shown in a curve in the original article together with a curve showing the values from the central station at Trebovice. A comparison of these two curves shows quite clearly that the heat consumption of the high-pressure station lies approximately 10 per cent lower than that of the medium-pressure station.

It is further to be kept in mind that the calculations for the Klingenberg station stipulate that two machine groups of 90,000 kw are at work, while the calculations at Trebovice are based on a total loading of 45,000 kw. If a comparison were made of the same total capacity, it would show that the difference in the two plants would be at least a further 2 per cent more favorable to the high-pressure plant. (First instalment of an article by Bruno Belohlávek in *The Steam Engineer*, vol. 2, no. 10, July, 1933, pp. 442 to 445, 7 figs., *d*)

VARIA

Federal Civil Employees in Germany

UNDER a German Act of June 30, 1933, every Federal civil servant must obtain permission in advance to carry on any supplementary occupation, even if it consists only in giving his wife assistance in her occupation. It is not compulsory, however, to obtain permission to work as an author or to carry on scientific, artistic, or lecturing activities, or (in the case of members of universities) to act as experts. Permission must be refused if the activity in question is incompatible with the dignity of a civil servant or with the public welfare, or if it is contrary to the interests of the service or constitutes an undesirable form of competition in the field of commerce or industry or the labor market. The permission may be conditional and limited to a certain period and may be recalled at any time. On the demand of a higher authority, every civil servant must accept any supplementary activity in the public service, even without payment. (*Engineering*, vol. 136, no. 3526, Aug. 11, 1933, p. 151, *g*)

WELDING

Thyratron Control of Welding in Tube Manufacture

THYRATRONS have been used in welding where a thyratron synchronous timer has been substituted for the cam-operated control switch. The present article describes a new circuit for low-capacity welders, again involving the use of the thyratron.

In an ideal welder of the resistance type, the metal at the points of contact should be heated to the plastic state and the pressure made sufficiently great to press the two pieces together in a forging manner that binds them to each other with a bond at least as strong as the single pieces. No change in heat treatment or oxidation should take place except at the welded point.

To prevent change in heat treatment or oxidation at other points, the heat should be confined to the point of welding by applying the welding current for comparatively short times. Because of the shortness of welding time, accuracy is extremely important, since a fraction of a cycle may be a large percentage of the total welding time.

The ordinary spot welder does not produce ideal welds for several reasons. With manual control, the welding time is necessarily long and relies on the operator's judgment, taught only by experience. If the judgment factor is removed by controlling the welding time by time-delay relays, the welds still must be made in comparatively long times owing to the non-synchronous action of the contactor destroying the accuracy when short times are attempted. Synchronous-motor-driven contacts have been used, but, even with most careful adjustment, occasional sparks occur which are detrimental to the contacts as well as the accuracy.

Grid-controlled rectifiers substituted for contacts provide the synchronous feature by their inherent property of ceasing to conduct only when the current stops and may be made accurate by proper control of the starting time.

The initial cost of thyratron control welders is higher than most of the usual types, but is claimed to be warranted because of the superiority of the results obtained. (H. W. Lord and O. W. Livingston, General Electric Company, Schenectady, N. Y., in *Electronics*, vol. 6, no. 7, July, 1933, pp. 186–187, and 206, 5 figs., *d*)

Apparatus for Welding Thermocouples

THIS is a description of an apparatus invented in Russia by a member of the "Vnidi," Engineer Velixon, for making pyrometers to be used on engine pistons. It is said that the usual couples, comprising copper, constantan, nickel, and nichrome, cannot be used here as they easily break at the bead because of the low elasticity of the wires.

In measuring temperatures by means of pyrometers in tests of high-speed Diesel engines at 1500 rpm, it has been found that the best couple is made up of annealed steel and constantan, but such a couple in an ordinary voltaic arc is difficult to weld, as the steel oxidizes, spits, and sparks. A new process has therefore been developed, the apparatus for which is shown in Fig. 10. One of the poles of the source of current (direct current is preferable but alternating may be used) is connected through fuse 2, knife-switch 3, and resistance 4 to terminal 5. The other pole is connected to a wire dipped into vessel 6 containing mercury 9 and oil 7. To weld the couple, the ends of the wires are twisted into a knot 8, the free end of one of the wires being connected to terminal 5. The knot 8 is then dipped into mercury and rapidly withdrawn. For an instant an arc is formed between the mercury and the wire knot while the latter passes through the oil, and this arc welds the tips of the wires together. As the welding takes place in a complete absence of air, excellent joint is produced. Moreover, no goggles are needed as the arc under a layer of oil is invisible. The apparatus can be used for welding wire of diameter from 0.05 to 2.0 mm. (0.0019 to 0.078 in.). (*Dieselestroyeniye* (in Russian), nos. 4–5, 1932, p. 38, 1 fig., *d*)

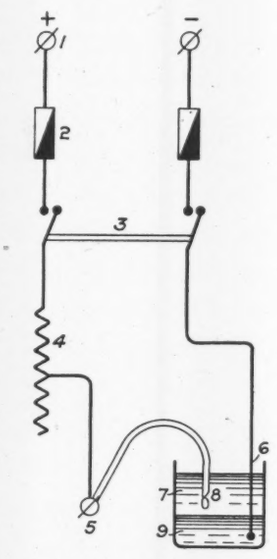


FIG. 10 VELIXON APPARATUS FOR WELDING FINE WIRES END TO END

SYNOPSES OF A.S.M.E. PAPERS

(Available Upon Request)

COPIES of the papers and reports abstracted on this and the following page may, until the supply is exhausted, be obtained free of charge by members of the A.S.M.E., by addressing the Secretary, 29 West 39th Street, New York, N. Y. A charge is made to non-members. Where papers are not numbered, please mention authors' names in ordering copies.

AERONAUTICAL ENGINEERING

Heating and Ventilating of Cabin Airplanes. Comfort for airplane passengers is being seriously considered, and aeronautical engineers are designing features for the airplane cabin that follow closely the comforts of railroad drawing-room cars and the facilities of the larger motor coaches. The adaptation is easily made, with alterations in weight and size. Heating and ventilating systems are replacing the rudimentary provisions of the past. The paper states the problems of heating and ventilating of cabin airplanes, gives available data, describes methods in use or attempted, and urges the mechanical and aeronautical branches of the profession to join in solving the problems. (Paper No. AER-55-7, by M. Gould Beard.)

Artificial Pay Load for Coming Commercial Airships. The most prominent field for the lighter-than-air vessel is across long stretches of water. The "Graf Zeppelin" confirms this by selecting as its first commercial venture the route between Germany and Brazil. There is a question whether the seagoing airship will merely be a high-speed, extra-fare auxiliary to the steamship or whether by radical improvement over present limited pay-load capacity it can be developed as a direct competitor to passenger-carrying ocean vessels at somewhat near to existing rates. The author suggests a number of means for artificially increasing pay load. (Paper No. AER-55-8, by T. L. Blakemore.)

Combustion Processes in Aircraft Engines. This paper presents three general types of combustion which occur in homogeneous mixtures of explosive gases (preflame oxidation, normal burning, and the explosive wave) and reviews available experimental evidence as to the combustion processes which actually occur in spark-ignition engines. Oxidation is detected optically by changes in absorption spectra and chemically by analysis of samples removed from the combustion chamber. The progress of flame away from the spark plug has been followed by visual, photographic, and electrical means, with simultaneous measurements of pressure development. Spectra of visible radiation and measurements of infra-red radiation, obtained through windows in the cylinder head, assist in analyzing combustion phenomena. The characteristics of preignition and knock are understood, but the exact mechanism of knock remains obscure. (Paper No. AER-55-9, by H. K. Cummings.)

Developments in Aluminum Alloys in Relation to Economies in Aircraft Construction. This paper reviews the mechanical properties and corrosion resistance of available aluminum-alloy structural materials, and as to the fabricating situation, discusses the status of technical information, equipment, and practises (forming, jointing, and corrosion prevention). A summary coordinates these matters to show what has been accomplished and the general direction of present developments, with the thought that the present lull in production provides an opportunity to plan for the future and conduct the indicated experimental work. The discussion is limited to the structural parts of aircraft, such as fuselage and wing and control surfaces, omitting power plant, landing gear, and accessories. (Paper No. AER-55-10, by C. F. Nagel, Jr., and G. O. Hoglund.)

Relation of Quality to Economics of Manufacture of Aviation Gasoline. Quality of aviation gasoline is the problem of the fuel manufacturer and the designer of aircraft engines. Present aviation gasoline is the result of demands for an increase of power output per unit of weight and displacement of aircraft engines. The improved engines represent designs intended to take full advantage of the best grades of gasoline available in sufficient quantities. Any future improvement in gasoline quality should bring about commensurate improvements in gasoline engines. The quality of aviation gasoline is thus setting the pace for improvement in aircraft engines of the spark-ignition type in use at present. (Paper No. AER-55-11, by G. G. Oberfell.)

Stainless Steel in Aircraft Construction. Stainless steel will assume its position in the aircraft industry when and where the urge is strong enough to study its possibilities, to acquire its technique, and to overcome the discouragement of first efforts. The first use of stainless steel in aircraft was in England. Tons of it were used in the construction of the "R-101." In this country a trend toward stainless steel is noted, particularly for air-transport units. (Paper No. AER-55-12, by E. J. W. Ragsdale.)

Recent Developments in Grading Fuels for Aeronautical Use. The subject of fuel grading is somewhat unknown to engine constructors, airplane operators, and others. In dealing with the grading of aviation gasoline, the author, instead of drawing on the great mass of experimental and published data on the subject, with the complexities of each of the component parts, and preparing an exhaustive discussion of one of the components, has chosen to present a general discussion of the factors involved. To this the author has added his opinion of the probable trend in the near future. Some of the points raised are to a degree controversial. The paper also includes a review of recent flight tests with various fuels. (Paper No. AER-55-13, by W. W. White.)

APPLIED MECHANICS

Self-Induced Vibrations. A "self-induced" vibration is defined as a phenomenon in which the alternating forces furnishing the energy to the vibration are controlled by the motion, in contradistinction to a "forced" vibration, where the force depends on time only. The following are examples of self-induced vibrations: (1) All bowed string or blown musical instruments, (2) the vacuum-tube oscillator, (3) fluttering of valves in air or water lines, (4) nosing of locomotives and street cars, (5) airplane-wing flutter, (6) certain cases of hunting of generators, and (7) certain cases of vibration of transmission lines due to wind. In physics and electrical engineering self-induced vibrations are common and often very useful, whereas most mechanical or machinery vibrations do not fall in this classification, since unbalance forces and other alternating forces unaffected by the motion are very common. This paper discusses methods of studying self-induced vibrations and describes several representative cases that have been studied by the author and his colleagues in the last few years. (Paper No. APM-55-2, by J. G. Baker.)

The Fatigue of Metals—Its Nature and Significance. The essential feature of "fatigue" failure in metals is a spreading crack. Studies of fatigue failure in single crystals of metal indicate that such cracks frequently start by slip along planes of atomic weakness. The study of fatigue failure of metals has shown certain limitations of the mathematical theory of elasticity when applied to actual non-homogeneous metals. The importance of the ability of a metal to resist occasional slight plastic action without starting a fatigue crack is emphasized. The relation between atomic strength and the strength of a multi-grained piece of metal is briefly discussed and a "crack-interference" hypothesis of fatigue failure suggested. The phenomenon of spreading cracks in metal under steady load at elevated temperatures is noted, and its significance discussed. (Paper No. APM-55-3, by H. F. Moore.)

The Present State of the Turbulence Problem. In this survey, the author first describes certain types of turbulent flow, following which he deals successively with the production of turbulent motion; the instability of the laminar motion; fully developed turbulence; momentum interchange and mixing lengths; and relations between the shearing stress at the wall and the mean velocity distributions. Finally he takes up the calculation of skin friction for simple cases of fully developed turbulence, especially for that of the flat plate. Although the methods outlined have often led to practically useful results, it is the author's belief that they should be considered only as advances toward the real goal of the turbulence theory. The derivation of turbulence phenomena from the hydrodynamical equations will, in his opinion, be possible only by the application of statistical methods. (Paper No. APM-55-4, by Walter Tollmien.)

Analysis of Stresses in an Elliptic Ring. Problems sometimes confront engineers, the analytic solution of which requires quite a knowledge of mathematics. The author illustrates this with the calculations required in an investigation of a wind-tunnel problem. The method used is intricate and tedious. A simpler solution may be arrived at by use of the graphical method. (Paper No. APM-55-5, by Merit P. White.)

Critical Torsional Oscillations of a Rotating Accelerated Shaft. The normal speed of actual engines is generally located beyond one or more critical speeds. These have to be crossed when the engine is started. The question then naturally arises as to which is the acceleration required to cross a certain critical speed, keeping the oscillation amplitudes below a given limit. This problem is here solved in the special case of undamped torsional vibrations and applied to a simple example. (Paper by M. Biot.)

FUELS AND STEAM POWER

Progress in Fuels. This report, contributed by the A.S.M.E. Fuels Division, was compiled by T. A. Mangelsdorf and F. B. Broughton. It covers fuels and fuel utilization, natural fuel production, coal carbonization and gas manufacture, steam generation, industrial furnaces and kilns, marine and locomotive developments, motor fuels, domestic heating, smoke and dust abatement, and engineering employment. Many references are given, and there is a supplementary bibliography. (Paper No. FSP-55-1.)

Progress in Steam Power. This report, contributed by the A.S.M.E. Power Division, covers the new installations for the year, the tendency in power-station design toward pressures as high as can be practically used without reheat, the rehabilitation of older plants by the superposition of a high-pressure boiler and turbine, the general important changes in boiler design, boiler furnaces and fuel burning, turbines and generators, power-station piping, and installations of the mercury-vapor cycle and the consideration of the use of diphenyl oxide for a binary cycle. (Paper No. FSP-55-2.)

Steam-Turbine-Plant Practise in the United States. From the great volume of available data on the design, equipment, service requirements, and operating results of the steam-electric-generating stations serving the larger power systems in the United States, the authors have endeavored to present a cross-section of existing turbine-plant practise. The principal subjects discussed include the selection and arrangement of steam turbine-generators, their condensers, and auxiliaries, together with an analysis of published test results for many large turbines and the service-reliability records of modern installations. While some economic considerations and other controlling factors underlying the principal features are outlined, the purpose of the authors is that of describing existing practise rather than of offering any recommended solution for the many problems involved. To assist in recognizing typical rather than exceptional practises, and widespread rather than personal or minority opinions, advantage has been taken of comments and suggestions from many individuals closely associated with the development of the art. (Paper No. FSP-55-3a, by V. E. Alden and W. H. Balcke.)

British Practise in Steam-Turbine Design. This paper reviews considerations affecting steam-turbine development in England. Turbines of the size and type required for the larger central stations are covered, although description of some of the smaller plants has been included. In discussing steam conditions, attention has been confined to general tendencies. Developments in turbine practise have been influenced by the plan to link up all the power stations by an interconnecting network of transmission lines. To cope with the increased demand, new large power stations will be constructed, which will have the advantage of high load factors and favorable conditions for base-load running. Illustrations are given of types of turbines and equipment. (Paper No. FSP-55-3b, by F. W. Gardner.)

Steam and Power in the Bleached-Sulphite-Pulp Mill. Methods of effecting economies in the use of steam in the paper industry are given, together with possibilities of water saving. After a brief description of the processes in a sulphite mill, a table is given of the probable requirements in steam and power for a 150-ton mill. The possibilities of combining the operations of pulp mill and a sawmill are stated, the sawmill having a surplus of waste wood for fuel and of low-grade wood for pulping and usually exhausting large quantities of steam to atmosphere. The effect on refractories of hog-fuel ash is related. (Paper No. FSP-55-4, by W. R. Gibson.)

Economic Balance Between Steam and Hydro Capacity. There is a popular fallacy that hydroelectric development and additional steam-plant generating facilities are competitive sources of power. Balancing one against the other is often discussed by engineers who are prejudiced in favor of hydro or of steam. It is the object of this paper to point out that each proposed hydro development should not be measured against an equivalent steam installation as a sole source of power, but that it is necessary to forecast the characteristics of the particular system in which additional capacity is required and to determine for the particular conditions whether the addition of steam or hydro will give the lowest total cost of power supply for the system. (Paper No. FSP-55-5, by K. McH. Irwin and J. D. Justin.)

RESEARCH

Effect of Lathe Cutting Conditions on the Hardness of Carbon and Alloy Steels. A quantitative study, based on hardness surveys, was made of the work hardening near the machined surface of steel forgings resulting from cutting with lathe tools. Comparisons were made of the work hardening resulting from changes in size, form, and composition and heat treatment of the steels cut. Observations were also made of the influence of cutting conditions on aging, corrosion resistance, chip hardness, structure near the machined surface of some of the steels cut and of the effect of annealing temperatures (100 to 700 C) on the surface hardness of some of the steels work hardened in the lathe tests. All lathe tests were made without cutting liquids and with sharp high-speed steel or cemented tantalum-carbide tools. (Paper by T. G. Digges.)

TEXTILES

Progress in Textiles. This report, contributed by the A.S.M.E. Textile Division, states that despite the materially reduced schedule of operation of the industry, all of its plant executives have been searching for means to eliminate waste and to develop improved methods and machinery, so that some of the mills have been operating successfully. Much progress has been made in scrapping obsolete mills and mechanisms, as well as the processes themselves. An important trend is the seeming willingness of the leaders to meet and discuss their problems. The subjects covered in the report include dyeing and finishing, cotton, process development, silk, wool, printing, and knit goods. A reference guide includes information in the various fields. (TEX-55-1.)

Sanforizing Process. The paper describes a machine that will treat a fabric so that its dimensions in warp and filling will be what is desired after the fabric is subjected to laundry washing or other cleaning process. The causes of the shrinkage of a fabric when subjected to full laundry treatment being mostly mechanical, an effective treatment to prevent shrinking may be found in some process of mechanically rearranging the fibers of the fabric (including changing the count of warp and filling) to the same extent that the fibers would rearrange themselves if subjected to a full laundry washing. Data are given of characteristic runs of different fabrics in the Sanforizing process. (Paper No. TEX-55-2, by S. L. Cluett.)

Cause and Effect of Recent Advances in Textile Machinery. There is an important general advance in the improvement of textile machinery. The cause is mainly in the necessity which the machinery manufacturers face of developing equipment for replacement rather than for expansion. A slight falling off in the rate of development began this year, due largely to the great expense which the work entails, but the rate is still far above normal. If the industry will refrain from employing high-production machines to increase total output, that is to say, if it will use such equipment strictly to decrease operating costs, it will have a splendid opportunity to eliminate or reduce the overproduction which now hampers it. (Paper No. TEX-55-3, by E. D. Fowle.)

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Business Conditions and Post-Graduate Study in Engineering

TO THE EDITOR:

Will continued industrial activity at a lower level than that of the boom years cause a continuation of the marked increase in graduate study in engineering? This is a question that faces colleges and universities throughout the country, and the answer seems to be in the affirmative, for institutions everywhere report considerable growth in graduate enrolments despite retrenchment and curtailment of graduate-fellowship funds.

The active interest in graduate study throughout the country is one of the pronounced trends in engineering education during the last decade. Enrolments in graduate courses increased from about 1000 in 1921 to more than 3000 in 1931, and since then the growth has been even more pronounced. Part of this increase has been attributed to the failure of recent graduates to obtain positions immediately after receiving their first degrees. These young men, wishing to maintain the normal rate of intellectual growth of their undergraduate days, have found graduate study the only outlet to their ambitions. They have further recognized a condition that has become apparent in industry, namely, that a distinct premium is being placed upon the additional year or years of study in the graduate school. No doubt, this condition reflects the opinion of executives that men with such training have demonstrated a faster growth in technical achievement and professional responsibility than others with less broadened horizons.

Institutions situated in different environments have met this demand in different ways. The commonest has been through the provision of more full-time graduate courses with a view to building more comprehensive curricula in advanced subjects. A very interesting variant of the customary method has been through the provision of post-graduate courses on a part-time basis. A number of institutions in urban communities have provided graduate courses in the evening during the past few years. Prominent among these are the Massachusetts Institute of Technology, Union College, Polytechnic Institute of Brooklyn, University of Pittsburgh, University of Pennsylvania, and Columbia University. The Polytechnic Institute of Brooklyn, as an illustration, introduced evening graduate instruction eight years ago, after twenty years of experience with evening engineering courses of college grade. It now has 250 graduate students in engineering and chemistry and last June graduated 22 with master's degrees. Among the 41 courses to be offered during the coming season are the following of interest to mechanical engineers: Graphical analysis of machines, kinematics in machine design, stress analysis in machine and structural elements, thermodynamics and heat-power engineering, and industrial metallurgy. In addition, there are a number of graduate courses in physics, mathematics, and chemistry.

This movement in engineering education will be watched carefully by engineers and educators. Apparently the answer to the moot question of the length of the engineering curriculum is being given through this normal evolution toward advanced study leading to higher degrees, rather than through the lengthening of the undergraduate curriculum itself.

ERICH HAUSMANN.[1]

Brooklyn, N. Y.

A Century of Progress in Fuel Technology

TO THE EDITOR:

Fuel technology—the art of burning fuel of various kinds—has been extensively studied for possibly twenty thousand years. The progress in the art up to 1833 was comparatively small and Dr. Hood[2] has covered the period of greatest progress, the last one hundred years.

The number of kinds of fuel has multiplied, the forms in which it is burned have been modified, and we believe that today we really know something about the process of combustion. We are, however, continually being astonished at some of the good results which were attained in earlier times, although, because of the lack of standardization of methods, it was not possible to secure adequate accuracy in the reporting of the results. Dr. Hood has quoted the work of Professor Johnson in 1844 and of Count Rumford, Benjamin Franklin, and others of an earlier date. He has not mentioned the experiments of Watt, Trevithek, and others in the early days of the steam engine, nor those of George and Robert Stephenson in the design of the locomotive firebox. It is an interesting fact that the ratings of boilers in those days were based on one cubic foot of water evaporated from 10 sq ft of boiler surface. We would, in the parlance of a few years ago, call this a 200 per cent rating. During the time which elapsed between Watt and the Centennial Exposition, this rating of boilers had fallen from about 6.5 lb of evaporation per square foot to about 3.5 lb of evaporation, the Centennial standard horsepower.

Since that time, we have made great progress and have learned how to burn increasing amounts of fuel under the boiler surface with increasingly better absorption of heat, until today, if no charge was made for feed pumps, forced and induced draft, or friction losses through the boiler, it would be possible to secure approximately 100 per cent efficiency from the combustion of the fuel. Indeed, our present-day bomb calorimeters are presumably 100 per cent efficient, since we base most of our testing work on the records obtained from

[1] Dean, Polytechnic Institute of Brooklyn.

[2] "A Century of Progress in Fuel Technology," by O. P. Hood. MECHANICAL ENGINEERING, June, 1933, p. 339–344.

them. From one pound of good coal, supposedly of 14,000 Btu heat value, a departure of 50 Btu between single calorimeter tests is usually an evidence of inferior technique in the handling of the apparatus.

It is also interesting to trace the attempts at proper boiler testing which commenced even before Watt's time and culminated in the work of J. C. Hoadley, who, in 1881, on the tests of the Pacific Mills boilers, obtained a boiler efficiency of 76 per cent without preheat and of 83 per cent when a preheater was used. W. C. Unwin, about the same time, tested a Lancashire boiler in England which gave an efficiency of somewhat higher than 80 per cent. In both of these tests, calorimeters were used; but I believe the honor of first using this instrument goes to Hoadley.

I must also refer to the work of Benjamin F. Isherwood, an honorary member of The American Society of Mechanical Engineers and Chief Engineer of the United States Navy during the Civil War, who, during his term of service, made many interesting boiler and combustion tests which were afterward printed in a quarto volume under the title of "Engineering Precedents." The testing work, after Hoadley's death, was taken up in this country by Charles E. Emery, Thurston, Kent, and others, while in England, Bryan Donkin, Michael Longridge, and W. C. Unwin, who was also an honorary member of the A.S.M.E., carried on much accurate quantitative testing.

It is also important to recall the work on smoke prevention and the perfection of combustion undertaken in England by Charles Wye Williams for the Steam Users Associations, whose experiments and researches have been quoted for half a century. Most of his work may be found in his two books on the "Combustion of Coals" and "Fuel, Its Combustion and Economy," which were published about 1854. He also published many papers which may be found in the Memoirs of the Literary and Philosophical Society of Manchester. Much pioneering work during this same period and the next two decades was done by Ser, Professor of Applied Physics at the L'Ecole Centrale des Arts et Métiers, Paris, whose publications were for many years a standard in that country. Modern work in France owes very much to Professor Ser's successor at the L'Ecole Centrale des Arts et Métiers, Prof. Charles Roszak. His researches and publications cover a wide field and his early death in 1929 at the age of 47 is much to be regretted.

Despite the higher efficiencies which are being obtained today, there is yet much work to be done in fuel technology. I believe that as a field for the engineer it offers many advantages and we shall probably be able to make such progress in the next century that I hope will put the last century as far in the shade as the work of the early experimenters is today.

GEO. A. ORROK.[3]

New York, N. Y.

TO THE EDITOR:

Dr. Hood's paper is of particular interest in that, while he presents in a very useful manner the early history of fuel technology, he very modestly refrains from tabulating the many important results secured by him and his associates in the U. S. Bureau of Mines, and by its predecessor in this work, the U. S. Geological Survey.

He has emphasized the progress of the earlier work that was accomplished just prior to and during the first half of the century now being commemorated. Most of us are familiar with the more rapid progress made during the latter half of the century, and some of us had direct personal experience dating back to wood-fired boilers, hand-fired stationary grates, and the earlier types of mechanical stokers.

The Bureau of Mines and others interested in fuel technology have done creditable work in connection with the accurate sampling of coal, the commercial evaluation of fuels, the studying of various methods of burning fuels, and the relation of capacity and efficiency of boilers to the analysis of different fuels, the fusing temperature, and other characteristics of ash, as well as similar research into the commercial use of gas, oil, and waste fuels of various kinds.

One of the outstanding accomplishments of the past twenty to thirty years is that in which low-grade bituminous coal, formerly burned at low capacities in inefficient, smoke-producing, hand-fired furnaces, such as Dr. Hood illustrates, is now burned efficiently, and without smoke, on stokers and in pulverized form in high-capacity furnaces, with which we are all familiar.

The two ingredients in low-grade bituminous coal that had to be conquered in bringing this about were the gas- and smoke-producing volatile and the high percentage of low-fusing-temperature ash, both of which had to be studied, contended with, and then subdued, in order to secure our present-day results. Troubles resulting from sulphur have not yet been fully solved.

Equally striking, in my opinion, is the important development that has taken place in the burning of natural gas, one of the most uniformly good and tractable fuels that could ever be desired. Comparatively few people realize the inefficient and wasteful methods by which this perfect fuel was often burned thirty years ago, when I first had experience with it. It seemed that the easier it was to burn, the easier it was to waste. Its more general use in localities where it was plentiful and cheap, appeared to be of little interest to owners or engineers of plants who were fortunate enough to have gas fuel available but who did not appreciate its possibilities. Today, it is burned with greater efficiency than coal or oil, in so far as completeness of combustion with low excess air is concerned. It is also more flexible over a wide range of control. These accomplishments were not brought about without fuel technology and the application of engineering knowledge and principles, many of which were first applied to the burning of coal and oil on a power-plant basis.

So much for the accomplishments up to the present time in a field in which development has been along the lines of higher capacities and higher efficiencies from whatever fuel is most economical on the dollar-heat-unit basis. But have we accomplished all that is possible in that direction? I think not. We are in many cases still paying a premium for low-ash, high-fusing-temperature coal, over other coal of lower grade. We are also paying a premium for oil and gas, because these fuels are more flexible in their control, or easier and simpler to use than coal.

I believe that there may still be accomplished:

First, the further development of a single furnace that will burn any of several kinds or qualities of fuels, including oil, gas, a wide variety of coal, and even refuse, whichever may be most advantageous to purchase from time to time on a dollar-heat-unit basis.

Second, greater flexibility in varying the rating to meet the furnace demands with the desired efficiency.

Third, further progress toward clearing up the discharge from chimneys of all kinds, from the smallest to the largest, not by resorting to expensive fuels, but by the use of equipment so satisfactory and efficient that the owner will have no alternative but to avail himself of these economies, with the

[3] Consulting Engineer, Orrok, Myers, and Shoudy. Mem. A.S.M.E.

additional satisfaction of knowing that he is contributing toward a clean community.

Some may think these aims have already been accomplished and that it is only a matter of salesmanship to put them into effect. It is true that better methods are known than are always installed, and that better results are possible than are always accomplished with such improved equipment already installed. There is more sales work to be done in putting into use the best equipment that has already been developed, and the operating engineer has not always fulfilled his responsibility for obtaining the best results from his equipment. Those who best know this problem, realize that there is still more to be accomplished, through further studies and developments in the technology of fuels and through improvements in combustion and furnace equipment, to bring about an actual realization of these goals. There still are problems in connection with the burning of low-grade fuels under steam boilers, in metallurgical furnaces, and for various heating demands, and these cannot be shifted by hydroelectric power or internal-combustion engines. It behooves the chemist and mechanical engineer, therefore, to work hand in hand toward the accomplishment of still better results in this field.

New York, N. Y. E. G. BAILEY.[4]

TO THE EDITOR:

I cannot help being impressed that, notwithstanding the great progress made in fuel technology in the past one hundred years, many boiler plants are still hand-fired and are being operated almost as inefficiently as they were one hundred years ago. I know this because I come in contact with it almost every day in my smoke-abatement work. This applies particularly to the small plant such as laundries, small commercial plants, and heating plants.

Despite all the progress mentioned in Dr. Hood's paper, heating boilers are still being sold and installed with little regard to the kind of fuel to be used in them. Boilers designed for hand-firing with anthracite coal are still being sold for use with bituminous coal and with oil. Some manufacturers and distributors of heating boilers are doing this. Many producers and distributors of coal are selling their product with little, if any, attention as to how it will be used. It is only within comparatively recent years that any heating boilers were sold other than those designed for anthracite. It is actually only within the last two or three years that there have been placed on the market heating boilers designed especially for oil and stoker-firing. Such conditions are certainly appalling when we stop to think of the great improvements Dr. Hood has described.

WILLIAM G. CHRISTY.[5]

Jersey City, N. J.

TO THE EDITOR:

In connection with the use of liquid fuel for domestic heating, there is a marked tendency, which developed during recent years, for the home owners to demand from their fuel suppliers more than a mere delivery of solid, liquid, or gaseous heating units. As a matter of fact, the consumer nowadays expects the company supplying the fuel to help him to operate his heating plant in such a manner that all worries about tending his fire and watching his apparatus will be taken away from him.

During the course of some 600 engineering calls in the winter season of 1932–1933, the writer was asked several times if th fuel-oil distributors were going to take the complete responsi · bility of operating the customer's plant after signing a yearly contract for fuel oil. This would include not only keeping the plant at all times supplied with a safe quantity of oil, but also adjusting burner, checking boiler operation, adjusting thermostat and control apparatus, and maintaining a service department ready to answer any trouble calls on immediate notice.

The fuel-oil distributors are not at the present time prepared to accept any such agreement; the larger refiners in fact are exercising a great deal of resistance against "burner service" other than in an advisory capacity. But it is reasonable to believe that within a few years from now some heating companies will contract with the home owners for the heating of their building during the cold season at a flat price. An estimate of the heating requirements for the building will be made by an experienced engineer; if any part of the installation is defective, it will be repaired or replaced, and coal, fuel oil, or gas will be supplied by the contractor, who will also take complete charge of servicing the installation during the season. A certain amount of gambling is involved in such a plan. In an unusually cold winter, the customer would benefit, while in a very mild winter the contractor would increase his profit.

Now that consumers are getting accustomed to "automatic heat," they wish to go a step farther and, even at a little higher cost than at present, have all worries about heating their home removed from their mind.

This is possibly the most striking angle of fuel technology for domestic heating.

Chicago, Ill. R. J. BENDER.[6]

Practical Plasticity Problems

TO THE EDITOR:

Mr. Eaton[7] has called upon those who are studying the various types of plastic flow of metals to explore the vast field of practical plasticity problems which accompany the production of steel from the molten metal to the finished product. Up to the present time, most of the plastic-flow research has been carried on by the users of metals, and problems relating to service applications have undoubtedly received more attention than have those of the producer. This paper may be considered as a challenge to the steel industry to take steps to provide the desired exact quantitative knowledge of plastic flow. A study of this kind must necessarily be made in the steel mill and the benefits come directly to the producer in the form of reduced chipping costs and rejections. It is impossible to say too much in favor of individual or cooperative research on the part of the steel industry because it must ultimately result in a more uniform product and the assurance of uniformity will allow increases in working stresses.

The effect of non-uniformity in material or heat treatment is shown by the variation in yield strength in 148 tests of rolled chrome-nickel steel covering a period of two years. Bars from which test specimens were cut ranged in size from $1/2$ to $2\,7/8$ in. and all bars had received the same heat treatment. While yield strengths as high as 152,500 lb per sq in. have been obtained and values from 100,000 to 110,000 are common, this material is rated for design purposes as having a yield strength of 70,000 lb per sq in. This shows how working stresses are affected by non-uniform material or treatment and

[4] Vice-President, Babcock & Wilcox Co. Mem. A.S.M.E.

[5] Smoke-Abatement Engineer, Hudson County, N. J. Mem. A.S.M.E.

[6] Combustion Engineer, Sinclair Refining Company. Jun. A.S.M.E.

[7] See "Practical Plasticity Problems," by George M. Eaton, MECHANICAL ENGINEERING, September, 1933, pp. 557–560.

indicates the improvements which may be expected from research in this field.

Mr. Eaton's condemnation of the application of conventional creep tests to the still-tube problem suggests a fertile field of investigation for the petroleum-refining industry. With full appreciation of the desirability of tests simulating service conditions, we must not lose sight of the fact that such tests may be not only difficult to make but also difficult to interpret. Tests in which the variables are controlled usually represent a departure from service conditions under which an infinite number of combinations of the variables may exist. Any attempt to explore the field of such combinations leads to a very extensive investigation and the material might easily become obsolete before the completion of the program.

In reference to the five fundamentals of creep tests for tubes used in refinery service, it is evident that each material must have a large number of tests. Mr. Eaton mentions the removal of tube sections after a wide range of times in service. For the purpose of investigation, each of these sections must be considered as a different material with a possible minimum of five conditions involved. If this is multiplied by three for the different portions of the cross-section, and repeated for at least three temperatures and three stresses, the result is a minimum of 135 tests for the original material. Even with tests of short duration, this is an extensive program, especially if it is desired to study several materials.

The suggested method of study of material from three annular rings of the tube cross-section requires careful consideration if it is desired to simulate service conditions. The application of stress to the inner annulus by means of flowing oil at the service temperature and pressure requires an external pressure equal to that normally exerted by the remainder of the tube. This, in turn, is dependent upon the creep characteristics of the inner annulus. A proper test of the center annulus requires a knowledge of the internal and external radial pressures exerted upon it by the inner and outer portions of the tube. The outer annulus must be subjected to an internal pressure equal to that transmitted through the inner portion of the tube. It is evident that an accurate evaluation of the radial stresses between the concentric rings requires a knowledge of the creep characteristics of the three layers of metal. This suggests a trial and error method of attack and a considerable increase in the number of tests necessary. Assuming that suitable tests could be made, three different creep curves would be obtained because of the difference in conditions. The problem of combining these three curves to determine what might be expected from the tube in service appears to offer more difficulties than would result from a test of the tube as a whole.

It may be suggested that hydrostatic rupture tests after various periods of time in service might offer a better solution of the still-tube problem than any form of creep test.

Considerable study has been applied to the mechanism of creep and much remains to be done. At the relatively low temperatures at which creep of steel may be detected, it is difficult to accept the explanation that it is due to a gradual change from the body-centered to the face-centered crystal lattice. An X-ray investigation of space-lattice changes under stress might help to prove or disprove the author's suggestion.

This paper will achieve a most valuable result if it awakens in the steel industry a realization of the importance of practical plasticity problems and leads to a cooperative effort to bring about their solution.

P. G. McVETTY.[8]

East Pittsburgh, Pa.

[8] Westinghouse Research Laboratories. Mem. A.S.M.E.

TO THE EDITOR:

Mr. Eaton's searching analysis has given engineers engaged in "creep testing" much food for thought. He has formulated some of the important aspects, and has shown that as regards fundamentals we are still much in the dark on certain phases of this branch of mechanical testing. The actual measurement of creep—even the definition of creep—has led to much discussion and a wide divergence of views. This condition results inherently, if we concede that creep is a function of the delicacy of the methods of measurement; moreover, detection of creep may be approached from two entirely different angles. We may maintain constant load and vary the temperature, or we may keep the temperature static and change the load; in either circumstance, the procedure is tedious and time-consuming. Further confusion results from the inability to decide upon the interpretation of the data obtained in a given test, which in part results from the obscurity surrounding the definition of true creep. Some investigators have determined what they consider to be reasonable figures for creep in a given steel, only to find their figures, methods, and judgment severely arraigned as being rough, inadequate, and misleading. Others have essayed tests of such a refined nature that their efforts are immediately decried as being too academic, far beyond the needs of industry, and calculated to hold up progress in the art. If the rheologist can shed light on some of the problems now connected with this subject, his contributions will be more than welcome.

Two fundamental conditions may be taken as responsible for the existence of the uncertainties in creep testing complained of by Mr. Eaton. One of these is the inherent clumsiness (for lack of a better word) of tensile testing equipment; for example, such a standardized property as the "elastic limit" at room temperature has been under fire for many years, and those best informed take refuge in the statement that the elastic limit is dependent on the delicacy of the testing equipment, and that if we could detect the point with sufficiently sensitive apparatus, the elastic limit of steel might actually be found to be a few pounds per square inch at room temperature. (Such a statement, if made in his day, might well have given William Fairbairn disturbing food for thought.) However, the theoretical metallurgist explains away our qualms by showing that such a condition is but a natural one for material with slip planes, and that by the saving grace of keying action our steels some way or other manage to stagger along under all kinds of abuse!

The other cause for the anomalies sometimes evident in the most carefully conducted creep tests is that frequently our steels and other alloys undergo marked changes of a truly fundamental nature when subjected to prolonged stress in certain temperature ranges within which the material is structurally metastable. Having started his test with ductile material, the investigator may find that its very nature has changed while exposed to the appropriate temperatures; it may have become embrittled when subsequently tested at room temperature, and even its chemical reactions toward certain media may have been entirely altered. All of this, however, makes more timely the searching questions introduced in the paper under discussion.

What, then, for the immediate future of creep testing? Are we, as engineers, to fall into a hopeless maze because as more and more refinements of temperature control and stress measurements are devised, we find greater divergence in our creep-rate estimates? Or are we to rely on "slap-dash" methods that can give us data only a little better than guesswork and which result in designs that time may prove to have been seriously defective? The answer to these questions may

be found in an analogy to present-day practise in design for room-temperature services. Let us concentrate on the development of short-time tests, data from which can be useful with suitable safety factors. In the meantime, adequately equipped laboratories will be searching out the fundamentals with tests as laborious as required. There is a real place for both schemes.

A percentage of all construction materials always has failed, and such history will for a long time yet continue to repeat itself, because of our lack of tests that can be applied on a *commercial* basis to detect hidden flaws. In spite of the fact that not until recently have we known of the sharply pronounced effects of corrosion fatigue, we still have the Brooklyn Bridge; and why? Because it is a monument of *engineering* sagacity. Therefore, we must today design high-pressure power lines, still tubes, and reaction chambers while lacking all the desired accurate information, leaning more heavily on the costly (from the standpoint of first costs) expediency of liberal safety factors. As more and more information accumulates, the designs can become more and more rational.

In other words, true creep occurs under surprisingly low loads even at room temperature, and the detection of the true limit of proportionality is a function of the sensitivity of the test apparatus. Since the macrophenomena that take place during the tensile testing of a piece of metal are the integrations of myriad microchanges, it seems only reasonable to cease splitting hairs in a bootless effort to define properties or to fix limits that are unattainable. Is it not better to take a sensible view of the matter, and, after proper investigation, to fix suitable practical limits for the definition of creep and the methods of determining it? Even as fundamental and widely used an engineering constant as Young's modulus is today only approximately stated.

In spite of many gaps in our knowledge, the situation is by no means gloomy. What are believed to be sufficiently reliable creep rates are known for a number of materials—certainly reliable enough for satisfactory design. The A.S.M.E., in collaboration with the A.S.T.M., has a committee that has been progressing painfully but surely toward a solution of the many problems touching this field. The word "painfully" is used advisedly, since the tests are costly and of prolonged duration. Supplementing the subcommittees on tensile tests are those on impact, metallography, corrosion resistance, fatigue, and others; recently, a subcommittee composed of experts from the tube-making and the tube-using industries has been added to the joint committee, for the purpose of studying problems connected with the testing of still tubes in the oil industry.

C. E. MACQUIGG.[9]

Long Island City, N. Y.

TO THE EDITOR:

I think that Mr. McVetty in his discussion overlooked the fact that the paper defines the function of the type of creep testing it advocates, as the detection of any service deterioration in resistance to temperature-stress cycles, rather than the isolation of precise characteristics. With this conception of the purpose of the tests it is clear that the number of tests mentioned by Mr. McVetty is not a fundamental requirement.

Mr. McVetty brings out a very good point when he suggests the possible value of rupture tests of still tubes after various periods of service. This comes very close to proving the resistance of the tube to the conditions under which the majority of failures occur.

The condemnation, which the paper presents, of long-time creep tests as applied to still tubes is not weakened by the discussion, and this is what must be expected when we realize that still tubes do not fail due to creep comparable to that occurring in these long-time tests.

G. M. EATON.[10]

Ambridge, Pa.

[9] Manager, Union Carbon and Carbide Research Laboratories.

Phenolic-Resin Glues for Plywood

TO THE EDITOR:

In connection with the paper by Phillip S. Hill on "Plywood as a Building Material,"[11] it should be noted that the weakest point in the plywood is the glue line, that a phenolic-resin glue line gives a better strength to the bond than the wood itself under extreme conditions of humidity, and that such glue is unaffected by bacteria or fungus growth.

The phenolic-resin glue line is not necessarily an expensive glue line. Synthetic-resin glue spreads have been made which show that with 8 lb of dry resin per 1000 sq ft of glue line, the shear strengths of fir, dry, averages about 240 lb, or as strong as the wood itself, and wet, averages about 200 lb per sq in. Even with a glue line as low as 4 lb of dry resin per 1000 sq ft, shear strengths of 200 lb dry and 150 lb wet were obtainable. The spreading of the colloidal glue is neither difficult nor expensive, and hot pressing, once the installation is available, is commercially possible on a large scale without excessive cost.

The synthetic-resin glue line is not softened by heat and hence it is possible to finish fir so that it will stand outdoor exposure, without checking and cracking under the paint. An inexpensive method of finishing is that of applying a piece of kraft paper to either side of the panel during the gluing operation using synthetic-resin glue. As the hot panel comes from the press, it can be painted with a water solution of synthetic-resin which cures practically from the heat of the panel and provides a size and protective coating which can be painted over directly and will stand weathering for many months. The gluing of asbestos to wood and many other types of construction which are made possible by the use of synthetic resin is of real importance to the use of plywood in construction, beyond the uses outlined by Mr. Hill.

ARTHUR J. NORTON.[12]

North Tonawanda, N. Y.

TO THE EDITOR:

Mr. Norton and the writer both agree that plywood properly glued with the necessary equipment, which is required for the handling of a phenolic-resin bond, is undoubtedly a better product than most of the commercial plywoods on the market today.

We are not able to say at this time whether plywood glued with resin glue has more structural strength than other commercial plywoods, but we do recognize that the hot-press resin process produces a waterproof plywood, and also a plywood which resists the attacks by bacteria and fungus growth.

The resin glue line, as Mr. Norton says, is not in itself an over expensive glue line, but he admits in the second paragraph of his letter that special equipment is required. We have investigated the cost of changing over a large plywood plant from cold-pressing to hot-pressing, and as this cost is very substantial, and as it is an item which would have to be absorbed

[10] Director of Research, Spang, Chalfant & Co., Inc., Mem. A.S.M.E.

[11] MECHANICAL ENGINEERING, June, 1933, pp. 355–357.

[12] General Plastics, Inc.

in glue-line cost, we believe it will be some time before the large plywood plants are willing to discard entirely their present equipment for equipment necessary to handle resin gluing.

PHILLIP S. HILL.[13]

Chicago, Ill.

The Human Side of Smoke Abatement

TO THE EDITOR:

Mr. Christy is to be complimented on his fine presentation of a very important, but unfortunately, neglected phase of a pressing widespread problem.[14] The technical development of smoke abatement has been much more successful than the human side of it.

Mr. Christy calls attention to the common practise of representing activity and prosperity by picturing smoking chimneys. In our city we have tried to point out that the use of this method of advertising is out of date.

Improper publicity does more harm than good. For years it was the custom of our smoke-abatement department to release weekly and monthly reports showing hours of smoke observed and comparisons with other similar periods. These reports had a tendency to cause the public to expect immediate and permanent results, and when they found that such were not forthcoming, there was dissatisfaction. Therefore we have discontinued the practise. Perhaps at the beginning this method was necessary. Of late years, however, our aim has been to educate the public to the fact that, to succeed, a smoke-abatement department must be a permanent organization, and that much good is continually being accomplished in proportion to the limited amount of money expended.

The main problem at present is the elimination of smoke from residence-heating plants. Until the use of smokeless fuels has been made practicable, the problem can be attacked only by the insistance of the installation of suitable heating equipment and by educating the home owner in the matter of proper firing methods. In spite of its apparent simplicity, the teaching of proper firing methods is extremely difficult.

To overcome this difficulty some demonstration apparatus was developed. It consists of two miniature furnaces, some funnels, and a soot-demonstrator. One of the furnaces is fired with coal, and as the smoke escapes from the chimney, it is ignited, and burns with a large flame. The effect of chimney size is demonstrated by means of funnels of several sizes and lengths. The soot demonstrator consists of two alcohol thermometers supported by a copper plate. One thermometer is separated from the plate by a small layer of soot. The heat from a candle in the back of the plate is transmitted through it to the thermometers, causing the alcohol in one to boil, whereas the one insulated with soot will show no action. The other furnace is an exact reproduction of the usual warm-air type. The casing can be removed and the furnace taken apart. Explanations in connection with the demonstrations are cut to a minimum, no technical terms being used. The demonstration equipment was used extensively last winter, and, judging by the interest shown, and the results obtained, it was useful to a marked degree in dealing with the human side of smoke abatement.

J. BILLETER.[15]

Salt Lake City, Utah.

[13] Chicago District Manager, Harbor Plywood Corporation.

[14] See "The Human Side of Smoke Abatement," by William G. Christy. MECHANICAL ENGINEERING, June, 1933, pp. 347–351.

[15] Assistant Engineer. Jun. A.S.M.E.

TO THE EDITOR:

The work in Hudson County, N. J., has stood out for several reasons. First, it was conducted on a county-wide scale, second, it was initiated, sponsored, and guided by an engineering school; third, engineers are in charge of every phase of it; fourth, it has continued to function normally during the depression; and fifth, excellent results have been achieved because of it.

As indicated in his paper, Mr. Christy has been able to gain cooperation from all sources and at the same time to get constructive publicity for his efforts. This has been one of the greatest factors in his success in Hudson County.

As a matter of contrast, it might not be amiss to add a few words regarding the status of the Cleveland Smoke Department with which the writer was connected for six years. In March, 1932, a new administration came into power and almost immediately disbanded the entire organization, with the exception of one inspector.

As a result, buildings and factories that for years have had clean stacks are now as bad as they were many years ago. Most of those who were using smokeless fuels have gone back to high volatile coal. One of the most striking features has been the smoking stacks of supposedly smokeless underfeed stoker jobs. This indicates conclusively that regardless of the equipment a certain amount of inspection and supervision is required.

The worst feature has been the fact that new installations and stacks are being made without proper checking of the plans. Many of these will take years to correct.

The general public has been apathetic. When there were unusually black days this past winter, a few comments were made in the newspapers but that was all. The Cleveland *News* recently carried at the top of its editorial page a picture of several smoking stacks and in glowing words welcomed them back to the horizon. After years of intensive smoke-abatement effort in Cleveland it would seem that much of it had fallen on barren ground. Observant people have noticed the difference in atmospheric conditions and are aware of the violations by individual stacks. On the whole smoke abatement appears to be in the luxury class as being a good thing when we are prosperous but not sufficiently desirable when we are poor.

H. K. KUGEL.[16]

Cleveland, Ohio.

TO THE EDITOR:

The policies suggested by Mr. Christy have been tried out for the past several decades without results satisfactory to the public, because of the failure of city authorities to recognize a difference between the prevention of smoke of prescribed density and the nuisances resulting from the discharge of solids and gases emitted from every stack serving a fuel burner, regardless of the color or density of the smoke.

The former problem supposedly presents no difficulties of solution; combustion engineers have long since demonstrated that furnaces can be operated without dense smoke. It requires a sufficient number of "observers" and police power to accomplish results.

Regardless of the density of the smoke emitted by a stack, however, from 1 to 5 per cent of all fuel fired is discharged into the atmosphere as solids, together with noxious gases, and the positive cessation of such discharge must be the goal of city authorities if cities are ever to be rid of the nuisances attribu-

[16] Rocky River, Ohio.

table to the emission from stacks serving fuel-burning furnaces.

The most economical means of burning fuel today is by the use of pulverized coal and mechanical stokers; each depends upon an agitated fire, especially the former, and such operation absolutely assures that a large quantity of light solids and fly ash will discharge from the stack. The density of discharge does not indicate the quantity of solids and gas being emitted and often the stack least objectionable to the eye as to color, is the greatest offender as far as air pollution is concerned.

Do not these facts indicate that previous policies employed to abate the smoke nuisance will have to be modified and that hereafter operators must provide equipment for the entrapment of solids and gas which would otherwise be emitted into the atmosphere if we are ever to be free from air-pollution from this man-made origin?

H. W. EVANS.[17]

Chicago, Ill.

TO THE EDITOR:

The question of smoke abatement has been solved by the engineer and is now up to the authorities. The present-day smoke nuisance is largely due to the inefficient way in which the smoke-abatement regulations are handled by local governing bodies.

However, the small house-heating plant will, under present conditions, defeat complete success even under perfect enforcement of existing regulations. The block-plant, furnishing heat and electric energy to the neighborhood, can solve this problem.

Because the years just ahead of us will demand the greatest possible economy, we shall no longer tolerate the heating of lakes and rivers with the condenser cooling water of the central stations with the wasting of all the by-product heat.

Therefore we shall see block-plants springing up wherever good common sense and sound engineering have their say so.

Then smoke abatement can be achieved and once again we shall have the full range of the sunlight in our city streets.

OSCAR A. KISA.[18]

Milwaukee, Wis.

TO THE EDITOR:

In connection with the comments by H. W. Evans on my paper, may I point out that it was not intended to cover every phase of the smoke problem; it was confined mostly to the human side. I cannot agree with the statement that the policies suggested have been tried out without satisfactory results. These policies are in effect in Hudson County with, I feel sure, as good results as could be expected considering present business conditions. The same policies were successfully used in Cleveland, St. Louis, Salt Lake City and to a large extent, in Pittsburgh. Even Mr. Evans' own city, Chicago, is using, very largely, the same policies now. Mr. Chambers informed me that they make only five or six prosecutions a year.

With respect to fly ash the drawback has been that until the present time there was no satisfactory method of measuring it. The Hudson County Smoke Ordinance, adopted January, 1931, prohibits fly ash as well as smoke. The excellent work done by Colonel Whitlock and A. C. Stern, covered by Stern's paper[19] at Chicago, will give us, I am sure, some satisfactory method of measuring the discharge of solids. Like any other undertaking, smoke abatement must wait for progress in engineering research as well as commercial development.

Mr. Evans apparently overlooks altogether the use of oil and gas as fuels, in which cases no solids are discharged unless, of course, considerable smoke is being made. All through this section of the country, oil is a fuel of major importance and its use is increasing. I believe the same thing is true all along the coast lines of our country. Natural gas is coming to be a very important fuel in large sections of the country.

I thoroughly agree with Mr. Evans that something must be done to stop the discharge of solids and obnoxious gases. Mr. Meller, in Pittsburgh, has been working along this line for several years. Our efforts in Hudson County are not confined to visible smoke, but also cover discharge of solids and gases where complaints are received.

Mr. Billeter emphasizes the practise of representing prosperity by picturing smoking chimneys. At the moment this seems to be increasing as we see it in publications and hear it over the radio. The old idea persists that this is a sign of increasing activity. The demonstration mentioned by Mr. Billeter is interesting and should be of value in the education of the public.

Mr. Kugel's account of conditions in Cleveland since discontinuing the Smoke Department only emphasizes the absolute necessity of continuous supervision by a regularly organized smoke department. This also shows that in a large number of cases the human element is responsible. As Mr. Kugel points out, many of these plants are well equipped with installations approved by the Smoke Department. When supervision is removed, no attention is paid to the smoke conditions.

WILLIAM G. CHRISTY.[20]

JERSEY CITY, N. J.

Drip Condensation

TO THE EDITOR:

In the July, 1933, issue of MECHANICAL ENGINEERING, page 410, in an article on "Drip Condensation," by F. A. Max Wulfinghoff, abridged by W. F. Ryan of the Stone & Webster Engineering Corporation, the following statement is printed in reference to tangential condensate drainage within surface condensers.

"This idea was first conceived by Ginabat in 1924. He devised a tube arrangement in which the condensate film dripping from one tube would hit the tube below tangentially."

Tangential condensate drainage is an American development, introduced by Worthington, upon which the original patent was issued to J. F. Grace upon December 12, 1905. It was first employed in a 3000-sq ft condenser installed at Boston Navy Yard in 1904. Worthington employed the devise both to drain condensate clear of air suctions per patent and as a high-heat-transfer dry-tube type condenser, and in combination with slanted drainage plates. Over 100 such Worthington condensers were in use at the time Ginabat is reported to have "first conceived" tangential drainage of condenser tubes.

J. F. GRACE.[21]

Harrison, N. J.

[17] Secretary, Citizens Board of Advisory Engineers on Smoke Abatement, City of Chicago.

[18] Consulting Engineer.

[19] "Measurement and Properties of Cinders and Fly Ash," by A. C. Stern.

[20] Smoke Abatement Engineer, Department of Smoke Regulation, Board of Health and Vital Statistics of Hudson County, N. J.

[21] Condenser Engineer, Worthington Pump and Machinery Corporation.

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets, and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Common Sense Applied to Motion and Time Study

COMMON SENSE APPLIED TO MOTION AND TIME STUDY. By Allan H. Mogensen. McGraw-Hill Book Co., Inc., New York, 1932. Cloth, 6 × 9 in., 228 pp., 110 figs., $2.50.

REVIEWED BY DAVID B. PORTER[1]

IN THIS book, Mr. Mogensen has assembled the best of the current periodical literature on the application of motion study in industry, and has bound this together with several chapters of his own. Although this collection of reprinted articles introduces some repetition of subject matter, it has the advantage of presenting various points of view and procedures of those who have been successful in this work. Such case material should be helpful to those who are endeavoring to introduce these methods. The author, in his own chapters, has treated the definitions and principles of motion study and the technique of analysis and construction of process and simocharts. A chapter on taking the motion picture explains the use of the equipment and goes far enough into photography to give the reader a working knowledge so that satisfactory results may be obtained. One chapter is devoted to "time study and rate setting." It describes the equipment used and gives an example of the synthetic construction of a job standard from standard data in the form of tables and charts. The book is well illustrated throughout with pictures, charts, and tables.

The reviewer has found the book a great aid in teaching motion study, but feels that the material is not arranged in the most logical order for teaching purposes.

Stop That Smoke!

STOP THAT SMOKE! By Henry Obermeyer. Harper & Brothers, New York, 1933. Cloth, 5 1/2 × 8 3/8 in., 289 pp., 2 illus., $2.50.

REVIEWED BY WILLIAM G. CHRISTY[2]

THIS BOOK covers practically every phase of the smoke problem. The polluted atmosphere of American cities is referred to as "aerial sewage" and smoke is called the "waster of cities." There is no mincing of words in stressing the appalling waste of fuel in this country, the tremendous damage caused by smoke, and its injurious effects on health. Air pollution is termed a challenge to health, and numerous authorities are cited to show its detrimental effects. It is estimated that, in urban and industrial communities, smoke cuts off 25 to 80 per cent of the sun's rays—including the ultra-violet and other health-giving rays. Now that we are realizing the connection between sunlight and health, the author believes it is time something is learned and done about the connection between sunlight and smoke. The vital interest of women in smoke abatement is emphasized, particularly the immense amount of extra laundry and cleaning required by soot and dirt from smoke. The major influence of smoke in the formation of fogs is pointed out. Smoke and fog are the greatest hazards to flying and we must do something to make a commercial success of aviation. The author correctly believes smoke abatement must be treated as a community problem and that it is essential to go after every offender without exception. He thinks we may have to resort to state or even Federal authority to stop smoke that drifts over city and county lines.

The author is a trifle optimistic about the smokelessness of gas plants and central stations, and he unduly stresses the by-product coke industry. It is also unfortunate that he has devoted so much attention to the dust counts made in 25 cities by Howard C. Murphy and his rating of these cities as to cleanliness. Readings taken in a few locations for a week or two in each city are far from being truly representative and the conclusions drawn are based on insufficient data. Considerable space is devoted to the history of smoke-abatement investigations and campaigns, particularly in Pittsburgh, Salt Lake City, St. Louis, Chicago, and New York. The legal phases are covered as well as the problems of enforcement. One good thought expressed is that we should have uniform regulations. The author agrees with many smoke authorities that powers of persuasion rather than prosecutions are most effective. The importance of domestic smoke is not overlooked. The boiler and furnace manufacturers are held largely to blame for the smoky condition of small heating plants. It is urged that every residence boiler or furnace be equipped with down-draft baffle, stoker, or oil burner, or burn a really smokeless fuel. A comprehensive bibliography on smoke is incorporated in the volume.

The book is quite readable and presents the most convincing arguments of the need for smoke elimination ever published. In his preface the author states he has only three points to make; first, that an emergency actually exists; second, that it can be overcome; third, that we must overcome it by ourselves. He concludes that not only can it be done, but that something must be done to eliminate this curse of our modern community.

[1] Associate Professor of Industrial Engineering, New York University, New York, N. Y. Mem. A.S.M.E.

[2] Smoke Abatement Engineer, Hudson County, New Jersey. Mem. A.S.M.E.

Books Received in the Library

ANALYTIC AND VECTOR MECHANICS. By H. W. Edwards. McGraw-Hill Book Co., New York & London, 1933. Cloth, 6 × 9 in., 428 pp., diagrams, tables, $4. This introduction to the study of mechanics is intended for students of mathematics and physics, and represents the course given in the University of California at Los Angeles. A thorough knowledge of calculus and some training in college physics are prerequisites. The range of topics is limited to those that are fundamental. Vector methods are used freely, frequently parallel with the analytical treatment.

COMMON SENSE ABOUT MACHINES AND UNEMPLOYMENT. By M. P. Taylor. J. C. Winston Co., Philadelphia, Chicago, Toronto, 1933. Cloth, 5 × 8 in., 173 pp., cloth, $1.50. Mr. Taylor argues that mechanization of industry has directly reduced employment and indirectly reduced trade, not as a necessary effect, but by unbalancing production and consumption. If the latter were kept adjusted, machinery would improve the average standard of living and advance material civilization. Mr. Taylor discusses the reasons why we have failed to use machinery properly, and examines the remedies that have been proposed.

DEBT AND PRODUCTION, the Operating Characteristics of Our Industrial Economy. By Bassett Jones. John Day Co., New York, 1933. Paper, 6 × 9 in., 147 pp., charts, tables, $2. This volume contains a paper entitled "A suggested method for the analysis of economic statistics," read before the American Statistical Association on March 6, 1933, and an "Introduction" occupying two-thirds of the book, which presents in plain English the conclusions drawn from his mathematical analysis.

The book is a quantitative study of our economy, approached from the productive end of the process. The author discusses production, employment, price and the relation of debt to production. Many assumptions in standard statistical works are criticized adversely. Mr. Bassett Jones concludes that physical production and debt have been growing at differential rates until a point has been reached where production can no longer carry the load of debt imposed upon it.

ELEMENTS OF ENGINEERING THERMODYNAMICS. By J. A. Moyer, J. P. Calderwood, and A. A. Potter. Fifth edition. John Wiley & Sons, New York, 1933. Cloth, 6 × 9 in., 192 pp., diagrams, charts, tables, $2.50. The purpose of this work is to present the fundamental principles of engineering thermodynamics as a foundation for the more advanced and practical applications of the theory. This edition incorporates many of the ideas and suggestions advanced at the conference of teachers held in 1929. The new material includes the thermodynamic treatment of uniform flow processes and new vapor tables for steam and ammonia. Additional attention is given to reversible and irreversible processes, and standard symbols have been adopted.

ENGINEER'S MANUAL OF ENGLISH. By W. O. Sypherd and S. Brown. Scott, Foresman & Co., Chicago, Atlanta, Dallas, and New York, 1933. Leather, 5 × 7 in., 515 pp., charts, diagrams, tables, $2. The first half of this work is a concise textbook of English composition, in which emphasis is placed upon correspondence, reports, articles, bulletins, specifications, and other forms of writing with which engineers are especially concerned. The second contains specimens of engineering writing, for study and analysis. Aside from its use as a textbook, the work is valuable as a reference book for engineering writers, offering much sound practical advice.

ERHALTUNGSWIRTSCHAFT, die wirtschaftliche Erhaltung der Fahrzeuge, Maschinen, Geräte und Weichen in den Ausbesserungs- und Betriebswerken der Deutschen Reichsbahn-Gesellschaft. By P. Kühne. Verkehrswissenschaftliche Lehrmittelgesellschaft bei der Deutschen Reichsbahn, Berlin, 1933. Cloth, 8 × 11 in., 512 pp., illus., diagrams, charts, tables, 30 rm. One problem to which the German Railway Company has given close attention in recent years is the reduction of repair costs. Shops have been rebuilt, methods standardized, and the principles of scientific management applied with marked results.

This handsome volume describes what has been done in detail. The layout of repair shops for efficiency, the organization of the staff, methods of inspection and repair, machine and tool equipment, the handling of stores, accounting methods, etc., are described fully. Aside from its value to railway men, manufacturers generally will find much of interest in the book.

ERMÜDUNGSFESTIGKEIT VON KESSELBAUSTOFFEN UND IHRE BEEINFLUSSUNG DURCH CHEMISCHE EINWIRKUNGEN (Mitteilungen der Materialprüfungsanstalt an der Technischen Hochschule Darmstadt, Heft 3). By C. Holzhauer. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 9 in., 73 pp., illus., diagrams, charts, tables, 6.50 rm. Reports investigations of the fatigue resistance of boiler plate under conditions approximating those of use. In addition to numerous physical tests, the effect of chemical action upon fatigue resistance was investigated for the first time. The methods and results are reported, with conclusions.

ÉTUDE MÉCANIQUE DU VOL DE L'AVION A L'USAGE DES TECHNICIENS. By M. Robin. Librairie Polytechnique Ch. Béranger, Paris et Liége, 1932. Paper, 6 × 9 in., 254 pp., diagrams, charts, tables, 70 fr. This work presents the course in aerodynamics of the airplane given at the Special School of Aeronautics. The theory of flight and of stability are presented in practical form, with numerous experimental coefficients and numerical applications. A collection of worked-out problems is included.

EVAPORATING, CONDENSING AND COOLING APPARATUS. By E. Hausbrand. Fifth English edition, translated from second revised German edition by A. C. Wright and enlarged by B. Heastie. D. Van Nostrand Co., New York, 1933. Cloth, 6 × 9 in., 503 pp., illus., charts, tables, $8. This edition consists of a reprint of the fourth edition (1929) with the addition of a chapter on heat exchangers in modern industrial practise and a select bibliography on heat transfer. The work has long been popular among designers as a convenient handbook of tables and formulas, covering a wide variety of practical problems.

FORSCHUNGSHEFT 360. DIE WERKZEUGMASCHINE UNTER LAST, FORMÄNDERUNGEN UND BEANSPRUCHUNGEN DER DREHBANK UNTER BETRIEBSLAST. By H. Kiekebusch. Verein Deutscher Ingenieure, Berlin, 1933. Paper, 8 × 12 in., 32 pp., illus., diagrams, charts, tables, 12 × 8 in., 5 rm. The author has investigated extensively the stresses generated in the various parts of machine lathes during operation, and the deformations that result. Test methods and results are given in detail.

GENERAL INDEX TO THE FINAL REPORTS OF THE PRESIDENT'S CONFERENCE ON HOME BUILDING AND HOME OWNERSHIP. Edited by J. M. Gries and J. Ford. President's Conference on Home Building and Home Ownership, Washington, 1933. Cloth, 6 × 9 in., 114 pp. This volume consolidates the indexes of the eleven volumes of Final Reports and overcomes the differences in terminology which confront users of the separate indexes. It enables one to locate quickly all the material upon topics which are discussed in several of the Reports.

GESETZMÄSSIGKEITEN DES DAUERBRUCHES UND WEGE ZUR STEIGERUNG DER DAUERHALTBARKEIT (Mitteilungen der Material prüfungsanstalt an der Technischen Hochschule Darmstadt, Heft 2). By H. Oschatz. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 9 in., 64 pp., illus., diagrams, charts, tables, 5.60 rm. This pamphlet is intended to give the practising engineer a knowledge of the causes of fatigue failures and of methods of prevention. In the first section the basic forms of fatigue fractures are presented and the relation between the forms of fractures and their origins explained. Part two describes investigations undertaken to increase fatigue resistance. Finally, methods of investigation are described.

DIE GLEITLAGER (LÄNGS- UND QUERLAGER) BERECHNUNG UND KONSTRUKTION. (Einzelkonstruktionen aus dem Maschinenbau, Heft 8.) By A. Schiebel and K. Körner. J. Springer, Berlin, 1933. Paper, 8 × 11 in., 70 pp., diagrams, charts, tables, 7.50 rm. A detailed study of the design and construction of plain, radial, and thrust bearings. Special attention is given to the relations between methods of lubrication and bearing design. Drawings of many typical bearings, illustrating the practice of leading concerns, are included.

DIE GÜTERWAGEN DER DEUTSCHEN REICHSBAHN, IHRE BAUART, BESTELLUNG UND VERWENDUNG, herausgegeben im Auftrage der Deutschen Reichsbahn-Gesellschaft, Hauptwagenamt in Berlin. Fourth edition. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 8 in., 39 pp., diagrams, tables, 1 rm. This handbook is intended to assist the German shipper to obtain suitable cars for his freight. It contains dimensioned sketches of the various types of freight cars of the German railroads, with information about their capacities, purposes, etc., and instructions for applying for them.

HANDBOOK OF MATHEMATICAL TABLES AND FORMULAS. Compiled by R. S. Burington. Handbook Publishers, Sandusky, Ohio, 1933. Leather, 5 × 8 in., 251 pp., tables, $2. The purpose of this book is to provide, in one compact volume, the mathematical formulas and tables needed by engineers, physicists, and students of mathematics. It contains the more important formulas and theorems of algebra, trigonometry, analytic geometry, calculus and vector analysis, a comprehensive table of series, derivatives and integrals, and also five-place logarithmic and trigonometric tables.

HENLEY'S TWENTIETH CENTURY FORMULAS, RECIPES, AND PROCESSES. Edited by G. D. Hiscox. Revised edition. Norman W. Henley Publishing Co., New York, 1933. Cloth, 6 × 9 in., 809 pp., diagrams, tables, $4. A collection of several thousand recipes relating to various trades and handicrafts, which has long been a popular reference book in workshops and homes. The new edition has been revised and modernized.

HOCHSCHMELZENDE HARTSTOFFE UND IHRE TECHNISCHE ANWENDUNG. By K. Becker. Verlag Chemie, Berlin, 1933. Cloth, 6 × 9 in., 227 pp., illus., diagrams, charts, tables, 21 rm. This valuable monograph reviews the widely scattered literature upon the infusible metallic carbides, nitrides and borides, and their alloys. Methods of manufacture, chemical and physical properties, and the metallography of these compounds are described, and much attention is given to their industrial uses as cutting tools, abrasives, etc. A list of patents is included, and a table of cutting speeds and feeds.

HOW TO BUDGET FOR PROFIT. By F. H. Rowland. Harper & Brothers, New York & London, 1933. Cloth, 6 × 10 in., 297 pp., charts, tables, $4. The subject is presented from the viewpoint of an executive who faces the problem of adjusting to the times a business which lacks all control data and apparently faces a loss during the next year. The essential steps in the analysis of such a business and in planning a budget are presented in detail, with samples of the necessary forms. Special attention is given to standard costs and sales estimates.

DER INGENIEUR, Ratgeber für die Berufswahl, Führer in den Beruf. Edited by Deutscher Ausschuss für Technisches Schulwesen. V.D.I. Verlag, Berlin, 1933. Paper, 6 × 8 in., 90 pp., 1.25 rm. The German Committee for Engineering Education sponsors this work on vocational guidance. It contains essays upon various branches of the profession which discuss the educational preparation necessary, the opportunities in each field, and other matters which may assist the beginner in choosing his lifework.

LABOR ECONOMICS AND LABOR PROBLEMS. By D. Yoder. McGraw-Hill Book Co., New York & London, 1933. Cloth, 6 × 9 in., 630 pp., diagrams, charts, tables, $3.50. This work combines an economical and sociological approach to the study of modern labor economics and problems. The major emphasis is on economic principles, but the problems are also considered fully, and recent suggestions for their treatment are evaluated in terms of the principles involved.

DIE LUFTVORWÄRMUNG IM DAMPFKESSELBETRIEB. (Monographien zur Feuerungstechnik, Bd. 9.) By W. Gumz. Second edition. Otto Spamer, Leipzig, 1933. Paper and board, 6 × 9 in., 332 pp., diagrams, charts, tables, paper, 20 rm.; boards, 21.50 rm. Air preheating in the boiler plant is thoroughly discussed in this monograph. The design and construction of preheaters, the economics of waste-heat utilization, the operation of preheaters, and their advantages and disadvantages are considered in detail. An excellent survey of the subject.

MIRRORS, PRISMS, AND LENSES. By J. P. C. Southall. Third edition. Macmillan Co., New York, 1933. Cloth, 5 × 8 in., 806 pp., illus., diagrams, tables, $4.50. Designed as an introduction to the theory of modern optical instruments, this work uses only the simplest mathematical processes, and presents the earlier and more elementary portions of the subject with much detail. This edition has been enlarged by a new chapter on the microscope, chosen as a typical optical instrument, and one in which various subjects having a bearing on the book as a whole are discussed.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN DES GHH-KONZERNS, Vol. 2, No. 6, May, 1933. V.D.I. Verlag, Berlin. Paper, 9 × 12 in., illus., diagrams, charts, tables, 4.25 rm. The first paper in this issue is a report upon the improvement of arc welds by high-grade covered electrodes. The second, of importance in connection with electric welding, is a mathematical investigation of the thermal stresses in an endless disk. The last reports the results of systematic investigations of the influence of chemical composition and thermal treatment upon the properties of case-hardened castings.

PETROLEUM REGISTER, International Annual Directory, Statistical Record and Equipment Catalogue. 1933 edition. Petroleum Register, New York, 1933. Cloth, 9 × 12 in., 457 pp., maps, $10. This work is a directory, statistical record, and buyer's guide, covering the American and foreign petroleum industry. The directories cover refiners, compounders, marketers, jobbers, producers, pipe lines, manufacturers of natural gasoline, royalty companies and drilling contractors very thoroughly, including information concerning capacity, financing, properties, officers, etc. There are lists of brands, of oil associations, and of the chief executives of companies. The statistical section presents essential statistics upon production and consumption for many years, exports, stocks, etc. The book includes maps of the oil-producing states, Colombia, Mexico, and Venezuela, showing the oil fields.

PHYSICAL MECHANICS. By R. B. Lindsay. D. Van Nostrand Co., New York, 1933. Cloth, 6 × 9 in., 436 pp., illus., diagrams, tables, $4. This new addition to the University Physics Series is intended as an intermediate text suitable for students who have had a year of general physics and a two-year course in general college mathematics. It endeavors to emphasize the fundamentals which are of supreme importance throughout all physics, pure, and applied. Many problems are included.

PRINCIPLES OF INDUSTRIAL ORGANIZATION. By D. S. Kimball. Fourth edition. McGraw-Hill Book Co., New York & London, 1933. Cloth, 6 × 9 in., 460 pp., illus., charts, tables, $4. The scientific background of production and the methods and mechanisms of management that have been devised to control it are clearly and concisely presented in this textbook for engineering students. The new edition has been thoroughly revised, but has been kept to a reasonable size, suited to instructional uses.

PRINCIPLES OF MECHANISM. By A. Vallance and M. E. Farris. Macmillan Co., New York, 1933. Cloth, 6 × 9 in., 335 pp., illus., diagrams, tables, $3.50. A compact textbook on the subject, intended for students of engineering and adapted to courses of from two to four semester hours. The book aims to develop logically the fundamentals of mechanism and to correlate them with the student's work in mathematics and physics, as a foundation for advanced courses in machine design.

PUBLIC UTILITIES AND THE PEOPLE. By W. A. Prendergast. D. Appleton-Century Co., New York and London. Cloth, 6 × 8 in., 379 pp., tables, $3. The former chairman of the Public Service Commission of the State of New York presents a timely discussion of utility companies in general and electric utilities in particular. Such controversial questions as the "power trust," holding companies, valuation, rates, regulation and public ownership are considered fully. The author's aim is to present an accurate, factual portrayal of the utilities which will guide public opinion.

RAKETEN-FLUGTECHNIK. By E. Sänger. R. Oldenbourg, Munich and Berlin, 1933. Cloth, 7 × 10 in., 222 pp., diagrams, charts, tables, 9.80 rm. In spite of the interest in rocket flight, it has been difficult to collect definite data upon propulsive forces, air forces, trajectories, and similar topics of concern to the engineer. The present book is intended to remedy this situation. The author has endeavored to collect the scattered information upon these topics and to present it from an engineering point of view.

RÉSOLUTION PRATIQUE DES PROBLÈMES DE DISCONTINUITÉ DE FONCTIONNEMENT DANS LES INSTALLATIONS DE CHAUFFAGE CENTRAL. By A. Nessi and L. Nisolle. Dunod, Paris, 1933. Paper, 7 × 11 in., 137 pp., illus., diagrams, charts, tables, 42 frs. For the past ten years these authors have been investigating theoretically the influences of the calorific capacity of buildings upon the operation of heating plants, and have from time to time published the results obtained. The present book completes their work to date. It presents a relatively simple method of calculation and illustrates its application by numerous examples.

STANDARDS AND SPECIFICATIONS FOR METALS AND METAL PRODUCTS. Miscellaneous Publication No. 120. United States Bureau of Standards, Washington, D. C., 1933. Cloth, 8 × 11 in., 1359 pp., illus., diagrams, tables, $3. As a supplement to its National Directory of Commodity Specifications, the Bureau of Standards began in 1927, the publication of an Encyclopedia of Specifications, with a volume on the wood-using industries. A volume on non-metallic minerals and their products appeared in 1930, and the present volume deals with metals and metal products, the series thus covering practically all building materials.

The present volume reproduces the substance and form of over sixteen hundred specifications, standards, and methods of testing which have been prepared by organizations authorized to speak for industry or the Federal Government. These cover ferrous and non-ferrous metals and manufactures, except machinery, vehicles, and electrical supplies. The work of some eighty organizations is combined in one convenient work, with cross-references and indexes, and with many illustrations.

STEAM, AIR, AND GAS POWER. By W. H. Severns and H. E. Degler. Second edition. John Wiley & Sons, New York, 1933. Cloth, 6 × 9

in., 480 pp., illus., diagrams, charts, tables, $4. An elementary text for use in courses in heat engineering where only a limited amount of work in the subject can be included. It aims to describe typical equipment clearly and briefly, and to explain the theory of such machines and devices. Only simple mathematical calculations are used. The new edition has been rearranged and revised by replacing obsolete material, and the problems have been replaced by new ones.

VALUE THEORY AND BUSINESS CYCLES. By H. L. McCracken. Falcon Press, New York, 1933. Cloth, 6 × 9 in., 270 pp., charts, $4. Recent years have produced many books on business cycles and price movements, in which highly divergent and often contradictory views have been presented. This, in this writer's opinion, is because of a failure to recognize that price movements and business cycles are problems in value theory. The present book is devoted to making this vital relationship clear.

In book one the embodied value theory is examined critically. The second book treates the commanded value theory in a similar way. The third book discusses the problem of business equilibration. The work is a timely discussion of pressing problems.

WHAT'S GOING ON

A.S.M.E. Annual Meeting Technical Program

THE technical program of the Fifty-Fourth Annual Meeting of the A.S.M.E., December 4 to 8, 1933, will include a discussion under the auspices of the Management Division of the problems of national recovery. Three speakers will lead the discussion at a round-table conference, dealing with the subject from the viewpoints of plant operation, the product, and the consumer.

Another session that promises to be important is the Symposium on Heat Transfer, under the auspices of the Process Industries Committee. Cooperating with the committee are the Iron and Steel, Power, and Petroleum Divisions. Papers are also being contributed to the symposium by the American Society of Refrigerating Engineers, the American Society of Heating and Ventilating Engineers, the American Society for Steel Treating, and the American Society of Naval Architects and Marine Engineers. The object of the symposium is to bring together information on actual heat-transfer rates as secured in the operation of various types of heat-exchange equipment.

Technical sessions are also being planned by various groups, as follows: Aeronautic, Fuels, Textile, Railroad, Iron and Steel, Oil and Gas Power, Materials Handling, Lubrication Engineering, Applied Mechanics (three sessions), Hydraulic (two sessions on current meters), Management (three sessions), Machine Shop Practice (three sessions), and Steam Power (two sessions, one on central-station power and another on industrial power). In addition, research committees are planning sessions on fluid meters, steam-table research, feedwater, and mechanical springs.

The Process Industries Committee is also planning a session on Air Conditioning, to be held jointly with the American Society of Refrigerating Engineers. The Committee on Relation with Colleges will substitute for the usual student conference a special session devoted to an interchange of ideas between practising engineers and engineering educators. The committee considers that the annual meeting presents an unusual opportunity for such an exchange of ideas and has chosen as the topic for the session "The Prominence and Character of Economic Subjects in Mechanical Engineering Courses." The opinions of practising engineers are desired.

The complete technical program of the meeting will be published in the November issue of MECHANICAL ENGINEERING. Because of a decrease in Society income, preprints of papers will not be available, but 1000-word abstracts will be available before and at the meeting.

Oil and Gas Power Meeting at Atlantic City

THE National Oil and Gas Power Meeting, held at Atlantic City, August 23 to 26, 1933, under the auspices of the A.S.M.E., Oil and Gas Power Division, opened with a technical session at which papers on "Welding of Diesel Frames and Parts," by Everett Chapman, and "Cause and Effect of Pressure Waves in Fuel-Injection Systems," by Ralph Miller, were presented. Mr. Chapman's paper precipitated a discussion on the relative advantages of various metals which might be used in Diesel-engine frames which was renewed after the Friday and Saturday morning sessions.

The Thursday morning session was given over to two papers; one on "Reducing the Performance of Solid-Injection Engine to Standard Conditions," by Prof. H. A. Everett, and the other on "Supercharging of Diesel Engines," by Charles G. Curtis. It was the unanimous opinion that Professor Everett's experiments clearly indicated that humidity may be ignored in calculating the probable performance of Diesel engines at various altitudes and that his final conclusions were much sounder than those previously offered. The author was encouraged to continue his experiment and it was suggested that in doing so the engine room and exhaust outlet be held at altitude pressure. Mr. Curtis called attention to the value of supercharging in gaining maximum power per pound of engine weight. It was pointed out in the discussion that American engine builders were extremely hesitant about adopting supercharging, which, in Europe, was practised in many plants with entire success. In this country where high wages made manufacturing costs high, the adoption of supercharging would go a long way toward a real reduction in engine costs.

Thursday afternoon was given over to recreation and committee meetings with a card party Thursday evening.

At the technical session on Friday morning, papers were presented on "The Effect of Controlled Turbulence," by Professors Huckle and Taylor; and "Low Compression Oil Engines," by Prof. Frederick Dutcher. In the discussion of Professor Dutcher's paper, it was brought out that there was a growing sentiment among engineers conversant with Diesel problems, that the solution of the low-price high-speed Diesel engine was to be found in the adoption of spark ignition and medium compression. Such engines could employ the framing and other parts of a standard gasoline engine and still be built at a low price. It was pointed out that spark ignition seemed to offer an advantage other than low manufacturing cost as fuel oil, when purchased in small lots, varied decidedly as to ignitability so that the presence of spark control insured ignition of the fuel charge which would make household fuel oil suitable in high-speed engines.

Friday afternoon was given over to recreation and a golf tournament. On Friday evening a banquet was held at which E. B. Pollister, president of the Busch-Sulzer Bros. Diesel Engine Co., spoke on "Sea Power and Diesel Engines." Mr. Pollister analyzed the need of the United States for adequate navy and merchant marine and said that the United States was deficient in naval strength as compared with Japan, the British Empire, France, and Italy after ships so old as to be considered obsolete by treaty limitations had been eliminated. He then discussed the need of modern Diesel auxiliary naval ships and said that because so few battleships were within the range of Diesel-engine sizes our naval officers would not depart from the established system of steam propulsion, which limited their Diesel activities to experimental development of suitable engines.

On Saturday morning the report of the Subcommittee on Oil-Engine Power Cost was presented. The report this year covered 20 per cent more plants than last year's report. Considerable discussion was stimulated and some discussors wanted the report interpreted. The Committee stated that the report presents the facts and allows each one to make his own interpretations.

In a paper on "Diesel Plant Operation," Ralph Troseth brought out the fact that too many Diesel power plants are insufficiently equipped with accessories and that they should have better engineering. In the discussion

that followed, it was pointed out that although some Diesel stations were inefficient, most of these were old plants and that such plants still existed was due in the main to the long life of the Diesel engine. A steam plant, would have been superceded by one, if not two, new installations, and these later ones would have reflected the advances in engineering art. It was also pointed out that the plants criticized in the paper were small stations or were operated but a short period each year so that the advantages of more equipment sometimes might not outweigh the cost.

Arrangements were made by the Oil and Gas Power Division to distribute copies of the papers presented at this meeting to members of the Division. None of these papers will be published in the A.S.M.E. Transactions. Members of the A.S.M.E. wishing copies of the papers presented should write at once to the Oil and Gas Power Division, A.S.M.E., 29 West 39th Street, New York, N.Y. Copies of all the papers except the report on cost data will be sent to members without charge.

President Roosevelt Appoints Science Advisory Board

PRESIDENT ROOSEVELT has rallied a group of eminent scientists as a Science Advisory Board to aid the government in coping with scientific problems.

The executive order establishing the new board is as follows:

"The National Research Council was created at the request of President Wilson in 1916 and perpetuated by Executive Order No. 2859, signed by President Wilson on May 11, 1918. In order to carry out to the fullest extent the intent of the above Executive Order there is hereby created a Science Advisory Board with authority, acting through the machinery and under the jurisdiction of the National Academy of Sciences and the National Research Council, to appoint committees to deal with specific problems in the various departments.

"The Science Advisory Board of the National Research Council will consist of the following members who are hereby appointed for a period of two years: Karl T. Compton, Chairman, President, Massachusetts Institute of Technology, Cambridge, Mass. (Mem. A.S.M.E.); W. W. Campbell, President, National Academy of Sciences, Washington, D. C.; Isaiah Bowman, Chairman, National Research Council, and Director, American Geographical Society, New York City; Gano Dunn, President, J. G. White Engineering Corporation, New York, N. Y. (Mem. A.S.M.E.); Frank B. Jewett, Vice-President, American Telephone and Telegraph Company, and President, Bell Telephone Laboratories, Incorporated, New York, N. Y.; Charles F. Kettering, Vice-President, General Motors Corporation, and President, General Motors Research Corporation, Detroit, Mich. (Mem. A.S.M.E.); C. K. Leith, Professor of Geology, University of Wisconsin, Madison, Wis.; John C. Merriam, President, Carnegie Institution of Washington, Washington, D. C.; R. A. Millikan, Director, Norman Bridge Laboratory of Physics, and Chairman of the Executive Council, California Institute of Technology, Pasadena, California."

Detroit Section to Sponsor Metal Congress Session and Inspection Trip

AS announced in the September issue, the 1933 Metal Congress will meet in Detroit, October 2 to 6. The Detroit Section of the A.S.M.E. is sponsoring a morning session on Wednesday, October 4, to be held at the Hotel Statler, as well as an inspection trip to the Kelvinator Corporation. Since that concern is furnishing both the transportation and luncheon at the plant, the Detroit Section requests that out-of-town members interested in this trip notify Paul H. Smith, 1530 Brooks Building, Detroit, Mich.

Proceedings of the Sixth Oil-Power Conference Available

THE Proceedings of the Sixth Oil-Power Conference, held under the joint auspices of Pennsylvania State College and the Oil and Gas Power Division of the A.S.M.E. at State College, Pa., June 8 to 11, 1932, has just been published.

It contains the following papers:

"Heating Fuels for Injection Engines," by E. A. Richardson.

"Spray Characteristics of a Jerk-Pump Fuel-Injection System," by O. F. Zahn, Jr.

"Surface-Volume Ratio as a Critical Factor in Automotive Diesel Combustion Chambers," by Julius Kuttner.

"Fuel-Spray Formation," by D. W. Lee.

"Combustion Knock in Diesel Engines," by P. H. Schweitzer.

"Fuel Injection in Gas Engines," by E. G. Beardsley and J. M. MacKendrick.

"Metallurgical Problems of the Diesel Engine," by R. J. Allen.

"Improving Operation and Overall Economy of Diesel-Engine-Driven Generating Stations," by H. W. Stalnaker.

"Inertia Supercharging of Engine Cylinders," by E. S. Dennison.

Copies of the Proceedings known as Technical Bulletin No. 16 may be secured from Pennsylvania State College at seventy-five cents a copy.

Oil-Engine-Power Cost Report Ready

THE fourth report of the Oil Engine Power Cost Committee of the Oil and Gas Power Division of the A.S.M.E. is now available. The report covers the cost of oil-engine power operation for the year 1932 in 140 plants with a total of 377 engines. In the 1931 report issued last year there were 119 plants reported with a total of 330 engines. Individual copies of the report may be secured in its preliminary form at ninety cents a copy or in quantities of ten or more at seventy-five cents a copy. Address The Secretary, A.S.M.E.

M. Charles de Freminville Honored

M. CHARLES DE FREMINVILLE, honorary member, A.S.M.E., has recently been elected to the presidency of the Société des Ingenieurs Civils de France.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after October 25, 1933, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the Secretary of the A.S.M.E. at once.

NEW APPLICATIONS

BAUD, ROBERT V., New York, N. Y.
BELINE, MARTIN B., Hoboken, N. J.
BURKE, JOHN J., JR., New York, N. Y.
DE VITO, FRANK M., New York, N. Y.
GRUBER, CHARLES W., Cincinnati, Ohio
HAWTHORNE, JOHN W., Watertown, N. Y.
HEBLER, WILLIAM O., Chatham, N. J.
HOLTZCLAW, HENRY J., Washington, D. C.
HUANG, PIENCHUN, West Peiping, China
KONKLE, CHARLES A., West Orange, N. J.
LEE, GEORGE W., New York, N. Y.
LEVY, SIDNEY B., St. Louis, Mo.
LINDENMEYR, CARL E., New York, N. Y.
LINDHAGEN, MANNE T., Stockholm, Sweden
MARSHALL, A. G., Martinez, Calif.
REDROW, ALLAN R., Washington, D. C.
SAKURAI, TADATAKE, New York, N. Y.
SHOVAR, CLARENCE B., Oakland, Calif.
SILBER, VICTOR, Brooklyn, N. Y.
SPERRY, ROGER S., Waterbury, Conn.
TURCO, LEOPOLDO, CARACAS, Venezuela, S. A.
WIGNER, GEORGE, Lawrence, Mass.
WILKENS, JOHN A., Brooklyn, N. Y.

CHANGE OF GRADING

Transfer from Associate-Member

BARNES, RALPH M., Iowa City, Iowa
ELLIS, D. W. V., Northern Rhodesia, Africa
HARDY, JOHN A., New York, N. Y.
OPPENHEIMER, P. H., New York, N. Y.
RHINEHART, JOHN R., Park Ridge, Ill.

Transfers from Junior

AVALOS-VEZ, BERNARDO, Mexico, D. F., Mex.
BIRUKOFF, ROMAN R., New York, N. Y.
CSISEK, JOHN J., West Portal, N. J.
DOWNES, GEORGE Q., JR., Prospect Park, Pa.
DOWNS, SEWELL H., Kalamazoo, Mich.
HATTON, MORTON, New York, N. Y.
JUDKINS, MALCOLM F., McKeesport, Pa.
KEMLER, EMORY, Pittsburgh, Pa.
LAWRENCE, S. F., New York, N. Y.
LOWREY, FRANK S., Rochester, N. Y.
MOULTON, CLARENCE F., Omaha, Nebr.
PICKLE, D. V., Austin, Tex.
SMITH, NILES B., Chicago, Ill.
STRANG, CORTLAND J., New York, N. Y.